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INTRODUCING THE CONTRIBUTORS

For the first time since this column has been appearing, it becomes necessary to " introduce " an author undoubtedly known to every reader of SCIENCE EDUCATION. The author of the first article in this month's issue is DR. JOHN DEWEY, Professor Emeritus of Philosophy, Columbia University. Professor Dewey's influence on American education has been so profound and far-reaching that it cannot be assessed in our generation. " Method in Science Teaching," first published in this JOURNAL in 1916, is indeed timely today, and its timeliness is emphasized by the pertinence of the introduction that Professor Dewey has written especially for its republication.

The discussion of the place of health education in science classes continues from the March number with DR. BERNHARD J. STERN's article, "Activities Useful in the Study of the Maintenance of Health." Dr. Stern teaches sociology in the extension division of Columbia University; among the courses he offers is one in the social aspects of medical care.

The report on the status of public-school science teachers in Colorado, prepared by ADA E. WINANS and F. C. JEAN, was presented on the program of the October, 1944, meeting of the Educational Section, Colorado-Wyoming Academy of Science. Miss Winans teaches science in the Senior High School of Scottsbluff, Nebraska. Her special interests lie in the area of instructional and personnel problems in guidance, and her graduate and undergraduate work was done at the Colorado State College of Education, Greeley, where Dr. Jean is chairman of the Science Division. Dr. Jean is senior author of the science survey books for colleges, *Man in His Physical Universe* and *Man in His Biological World*.

The work described by MERVIN E. OAKES (" Explanations of Natural Phenomena by Adults ") was done in conjunction with a larger investigation, *Children's Explanations of Natural Phenomena,* now in press. Dr. Oakes, who is Advertising Manager of SCIENCE EDUCATION, teaches at Queens College of the College of the City of New York, and is a member of the Science Council, Federation of Science Teachers Organizations, New York City, and chairman of its Committee on Research and Experimentation.

The description of procedures and planning in Central High School, Trenton, New Jersey (" Present and Future Science Courses ") was prepared by J. GORDON MANZER, head of the science Department in that school and president of the New Jersey Science Teachers Association. A brief paper by Mr. Manzer appeared in an earlier issue of this JOURNAL, that for February, 1944.

" Toward a More Adequate Science Education " is an attempt to explore the question, What is science? ZACHARIAH SUBARSKY, chairman of the biology department at the Bronx High School of Science, New York, read this exploration at a meeting of department chairmen in November, 1944.

The Department of Educational Trends carries the report of a committee consisting of KARL W. BIGELOW, R. J. HAVIGHURST, F. J. KELLY, and K. LARK-HOROVITZ, chairman. " On the Teaching of the Basic Sciences " is reprinted from *The American Physics Teacher*. Dr. Bigelow is Director of the Commission on Teacher Education, American Council on Education, and Chairman of the Council on Cooperation in Teacher Education. Dr. Havighurst is Professor of Education and Secretary of the Committee on Human Development of the University of Chicago. Dr. Kelly is Director of the Division of Higher Education in the United States Office of Education. Dr. Lark-Horovitz is head of the department of physics at Purdue University.

SCIENCE EDUCATION

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METHOD IN SCIENCE TEACHING

John Dewey
Columbia University

This article was the address of Dr. Dewey before the Science Section of the National Education Association at its meeting in New York in July, 1916. It seems particularly appropriate that this should have been published as the lead article in Volume 1, Number 1, of *General Science Quarterly* (now Science Education).

The brief note which Dr. Dewey has contributed as an introduction is sufficient to explain why the present editor is proud to present this reprint.—S. R. P.

Introduction

Almost thirty years, the allotted period of a generation, have passed since the accompanying article was written. The editor of Science Education has honored me with an invitation to say a few words in connection with its republication. There are of course some changes that would have to be made if the article were first written today. But in the main I feel that the course of events has reinforced what is basic in the article. In particular, I think two recent educational movements have strengthened its relevancy to present conditions.

In the last few years an increasing number of voices have engaged in a virtual attack upon the place held by science teaching in our schools. Influential voices plead for subordination of science to the culture which they say can be attained only by study of the literary products of the past. For science, they say, is concerned with material, not with humane, affairs. They set science and the concerns of man as man over against each other, and proclaim that the rightful supremacy of the latter demands the educational subordintion of science. The entire cogency of their position depends upon identification of science with a certain limited field of subject matter, ignoring the fact that science is primarily the method of intelligence at work in observation, in inquiry and experimental testing; that, fundamentally, what science means and stands for is simply the best ways yet found out by which human intelligence can do the work it should do, ways that are continually improved by the very processes of use.

The same voices are urging a separation of the vocational training which they believe to be suited to the capacity of the many from the higher liberal and cultural education which they think appropriate to a much smaller number of persons. As against this position, I think it is as important now as it was a generation ago, perhaps more so, to insist that for the many who are not going to become specialists in science " that value of science resides in the added meaning it gives to the usual occurrences of their everyday surroundings and occupations." I would add, with emphasis, that some insight into and command of scientific method and material is increasingly the only effective way by which this added meaning can be made a reality. When the applications of science are in fact shaping more and more the conditions of the world in which we must live and act, whether we like it or not, the attempt to separate science from liberal and humane interests is nothing but an act of withdrawal which if it be carried into effect will increase the already too great lack of preparation to understand the world in which we live. And without understanding, how can we hope to act with intelligence?

JOHN DEWEY.

March 1, 1945.

METHOD means a way to a result, a means to an end, a path to a goal. Method therefore varies with the end to be reached. Without a clear notion of the end, we cannot proceed intelligently upon the journey toward it. When we try to state the end of science teachings we are, however, likely to find ourselves involved in such vague generalities that all might use the same words and yet differ radically about actual method of procedure. It is therefore only to make clear my own point of approach and not to foreclose discussion that I say that the end of science teaching is to make us aware what constitutes the more effective use of mind, of intelligence. To give us a working sense of the real nature of knowledge, of sound knowledge as distinct from mere guess work, opinion, dogmatic belief or whatever. Obviously science is not only knowledge, but it is knowledge at its best, knowledge in its tested and surest form. Educationally then what differentiates its value from that of other knowledge is precisely this superior quality. Unless it is so taught that students acquire a realizing sense of what gives it its superiority, something is lost. If we ask how this superior type of knowledge came into existence we find that men have been working their minds, more or less effectively for many thousand years, and that for a very long time it was less rather than more effectively. But the most efficient ways of using or working intelligence have gradually been selected and cultivated. And science as a personal power and resource is an equipment of all those found more successful, most effective. A man may have a good deal of cultivation, a good deal of information, correct information at that, about things, but if he has never made a first hand acquaintance at some point with scientific ways of dealing with a subject matter, he has no sure way of telling the difference between all-wool knowledge and shoddy goods. He has no sure way of knowing when he is using his mental powers most capable and fruitfully. An ability to detect the genuine in our beliefs and ideas, the ability to control one's mind to its own best working, is a very precious thing. Hence the rightful place of science in education is a fundamental one, and it is correspondingly important to see to it that methods of teaching are such as to fulfill its true pupose.

When we pass from this generality, it seems to me that the first need is to discriminate certain stages in the educational development of science. The first stage belongs of necessity to the elementary school, for I do not think that any amount of pains and ability in the high school can make up for a wrong start or even a failure to get the right start in the grades. This is contrary in appearance to a common assertion of secondary teachers that they would prefer that their pupils came to them without any science instruction at all—which is parallelled by a similar statement on the part of the college teachers. I think the inconsistency is only in appearance. The remark is really proof of the necessity of a right start. I do not believe that the problem of successful science will be met until teachers in college and high school exchange experience with those in the elementary school, and both take a mutual interest in one another's work.

At this stage, the purpose should be to give a first hand acquaintance with a fair area of natural facts of such a kind as to arouse interest in the discovery of causes, dynamic processes, operating forces. I would emphasize the clause regarding "of such a kind." I think the chief defect, upon the whole, in our present elementary nature study is that while it may arouse a certain interest in observation and accumulate a certain store of information, it is too static, and hence too miscellaneous. By static I mean that observation is directed in some active process. No amount of information of this sort can supply even a background for science. Space, however, forbids my dwelling upon this point, and its underlying point can perhaps be brought out by reference to something which lies within the high school program, namely, so-called general science. Like the nature-study movement the tendency to general-science courses is animated by a praiseworthy desire to get away from the specialized technicalities of a highly matured science. I will not say that these reduce themselves for the average beginning student to mere acquisition of a vocabulary, though there is danger of this. But except with the few this science of the accomplished specialist remains, even when fairly well understood, just an isolated thing, a thing of a world super-added to the everyday world, when it ought to be an enlightening and an intellectual control of the everyday world.

As an attempt to get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist, the general-science tendency has, as I have just said, its justification. But I have an impression that in practice it may mean two quite different things. It may take its departure from sciences which are already differentiated, and simply pick out pieces from them, some from physics, some from chemistry, some from physiography, some from botany, etc., and out of this varied selection form something to serve as an introduction to sciences in a more specialized form. Now this method I believe to be of the static type after all. It gives scope for variety and adaptation, and will work with the right teacher. But urged as a general movement, I believe it retains the essential mistake of any method which begins with scientific knowledge in its already-made form, while in addition it lends itself very easily to scrappy and superficial work, and even to a distaste for the continued and serious thinking necessary to a real mastery of science.

General science may, however, have another meaning. It may mean that a person who is himself an expert in scientific knowledge, forgets for the time being the conventional divisions of the sciences, and puts himself at the standpoint of pupil's experience of natural forces together with their ordinary useful applications. He does not, however, forget the scientific possibilities of these experiences, nor does he forget that there is an order of relative importance in scientific principles—that is to say, that some are more fundamental, some necessary in order to understand others, and thus more fruitful and ramifying.

While then he may take his subject-matter from any of the ordinary and more familiar materials of daily life, he does not allow that material in its obvious and superficial form to dictate to him the nature of the subsequent study. It may be varnish or cleansers, or bleachers, or a gasoline engine. But he never for a moment allows in his educational planning that thing to become the end of study; when he does, we have simply the wrong kind of elementary nature study over again. To him, as a teacher, the material is simply a means, a tool, a road. It is a way of getting at some process of nature's activity which is widely exemplified in other phenomena and which when grasped will make them more significant and more intelligible. While the student's attention may remain, so far as his conscious interest is concerned, upon the phenomena directly in front of him, it is the teacher's business to see that he gets below the surface to the perception of whatever is scientifically in the experience. This need not be labelled a principle or law—in fact, if it is so labelled at first, the name principle or law will be merely a label. But if further material is selected so that what the pupil got hold of before serves as a means of intellectual approach and understanding, it becomes a principle or law for him: a law of his own thinking and inquiries, a standpoint from which he surveys facts and attempts to reduce them to order.

This same method of procedure means of course that choice is made in fixing the kind of familiar material with which one sets out. The interests and occupations of the environment will play a part. A farming environment would tend to provide one point of departure, a district in which electric apparatus was made another, a railway center a third, and so on. But in each case, there will always be room for choice between material which tends to begin and end in itself and that from which something may be easily extracted which will give pupils a momentum to other things.

My point may perhaps be stated by saying that the right course lies between two erroneous courses. One method is the scrappy one of picking up isolated materials just because they happen to be familiar objects within the pupil's experience, and of merely extending and deepening the range of the pupil's familiarity, and then passing on to something else. No amount of this will make an introduction to science, to say nothing of science, for an introduction leads or draws into a subject, while this method never, save by accident, gets the pupil within the range of problems and explanatory methods of science. The other erroneous course is taken when the teacher's imagination is so limited that he cannot conceive of science existing except in the definitely segregated areas, concepts and terms which are found in books under the heads of physics, chemistry, etc., and who is thus restricted to moving within these boundaries. Such a person forgets that there is no material in existence which is physical or chemical or botanical, but that a certain ordinary subject matter *becomes* physical or chemical or botanical when certain questions are raised, and when it is subjected to certain modes of inquiry. What is desired of the pupil is that starting from the ordinary unclassed material of experience he shall acquire command of the points of view, the ideas and methods, which *make* it physical or chemical or whatever.

I return to what I said at first about the dynamic point of view as the really scientific one, or the understanding of *process* as the heart of the scientific attitude. What are called physics and chemistry deal in effect with the lawful energies which bring about changes. To master their method means to be able to see any observed fact, no matter how seemingly fixed and stubborn, as a change, as a part of larger process or on going. In this sense, they are central (along with mathematics which alone deals with the fixed, the formal and structural side of the fact) in all scientific understanding. There is a sound instinct in the tendency to insist upon them as the heart of the secondary course in science and to look with jealousy upon whatever narrows their sphere of influence. But it does not follow that the material which is found in the text which segregates certain considerations under the heads of physics or chemistry is the material to begin with. That is the fallacy against which I have been arguing. Plant and animal life, the operations of machines and the familiar appliances and processes of industrial life, are much more likely to furnish actual starting material. What the principle calls for is that the pupil shall be *led* in his study of plant and animal life, of machine and its operations, to the basic operations which enables him to *understand* what is before him—to be led inevitably to physical and chemical principles. Nothing is more unfortunate for education than the usual separation between the sciences of life and the physical sciences. Living phenomena are natural and interesting material from which to set out, especially in all rural environments. But they are educationally significant in the degree in which they are used to procure an insight into just those principles which are not plants and animals, but which, when they are formulated by themselves, constitute physics and chemistry. It is the failure to carry nature study on to this insight which is responsible for its pedagogically unsatisfactory character; and the movement toward general science will repeat the same unless it keeps the goal of physical and chemical principle steadily in view.

An extension of the method I have spoken of should in my judgment constitute the bulk of the secondary course in science, which ideally should be continuous throughout the four years—or the six. We must remember that although in school we are always treating pupils as embryonic scientists who somehow get interrupted and cut off before they get very far, the great mass of the pupils are never going to be scientific specialists. The value of science for them resides in the added meaning it gives to the usual occurrences of their everyday surroundings and occupations. None the less, we want a high school which will tend to attract those who have a distinct calling for specialized inquiry, and one which prepares them to enter upon it. I can only express my belief that there are many more such in the pupil population than we succeed at present in selecting and carrying on, and that I believe this is largely because we follow to so great an extent the method of feeding them all from the start as if they were full-fledged minute specialists. As a result large numbers who might otherwise be drawn later into the paths of scientific inquiry now get shunted off into the more concrete and appealing paths of engineering, industrial invention and application—simply because they have been repelled by a premature diet of abstract scientific propositions, lacking in meaning to them because abstracted from familiar facts of experience.

I believe there are scores if not hundreds of boys, for example, who now go from technical courses of physics into automobile factories and the like, who, if they had begun with the automobile under a teacher who realized its scientific possibilities, might have gone on into abstract physics.

I can sum up by saying that it seems to me that our present methods too largely put the cart before the horse; and that when we become aware of this mistake we are all too likely to cut the horse entirely loose from the cart, and let him browse around at random in the pastures without getting anywhere. What we need is to hitch the horse of concrete experience with daily occupation and surroundings to a cart loaded with specialized scientific knowledge. It is not the business of high school science to pack the cart full—that will come later. It is its business to make such a good job of the hitching that every pupil who comes under its influence will always find in himself a tendency to turn his crude experiences over into a more scientific form, and to translate the bare science he reads and hears back into the terms of his daily life. When we do this, we shall find, I am confident, the crop of scientific specialists increased, not diminished, while we shall have a citizenship of men and women really intelligent in judging the affairs of life.

ACTIVITIES USEFUL IN THE STUDY OF THE MAINTENANCE OF HEALTH

BERNHARD J. STERN
Columbia University

ACTIVITIES in the field of health education utilize the full gamut of teaching techniques and methods. They involve laboratory work and class demonstrations, field trips, community surveys, oral and written reports, reading, discussions, symposia, debates, exhibits, the showing of films, slides, and photographs, and guest lecturers. They stem from the health problems of the individual, the school, the family, the community, the region, the state, the nation, and the world. Moreover, they are concerned equally with the diffusion and extension of existing scientific information and with the utilization of such knowledge in the formulation of personal and community attitudes and behavior.

The activities proposed have been organized into four major groups. In the first are activities designed to show the implications of present knowledge concerning the selective and balanced exchange of materials and energy between the human body and the external world. The activities suggested in this group deal with the various bodily processes, particularly circulation of the blood, respiration, and digestion, by which the human organism is able to maintain persistent internal stability—the steadiness of bodily temperature and of the mild alkalinity and sugar concentration of the blood—and so maintain good health.

The second group of activities is centered on the manner in which an individual can provide the necessary materials and energies for the human organism and avoid harmful substances. Activities in the third group are concerned with an individual's efforts to keep well through medical care—when a doctor is to be consulted; the relative competence of physicians and healing cults; the procedures and theories underlying the work of a physician; the quantity and quality of the resources for medical care in the community. The fourth group of activities takes up the extent and effectiveness of protective measures administered by public health authorities for the control and prevention of human diseases, particularly communicable diseases.

THE HUMAN BODY: MAINTENANCE OF INTERNAL STABILITY

Basic to the entire problem of the maintenance of health and the avoidance of disease is knowledge of the human body and its functioning. The chief interest here is not in disease states and in abnormal pathological cases. It is in the normal processes by which the average human body maintains its internal equilibrium as an organism in interaction with its external environment. Lacking the delicate internal stability maintained by all processes of the organism, with the circulating blood playing a major role, the organism would perish. The body is equipped, moreover, with defenses against such dangers as the invasion of pathogenic microorganisms and can be integrated for survival in case of emergencies by a process in which the adrenal glands play an important role. The following activities are designed to increase students' understanding of these normal processes and to enable them to guide their behavior in the interest of proper care of the body.

Discuss the substances that enter the blood stream—digested foodstuffs, water, oxygen, wastes, new blood cells, hormones, toxins, and pathogenic microorganisms; then discuss the responses of the organism which tend to keep the composition of the blood stable—changes in the respiratory rate, changes in excretion and storage, changes in rate of circulation, and changes in blood pressure.

List other factors which tend to change the conditions of the blood—hemorrhage, exercise, exposure to changes in pressure (for example, going to a mountaintop, diving, high-altitude flying, parachute jumping), increase or decrease in temperature, bacterial invasion. Put opposite each the responses of the organism which tend to keep the condition of the blood stable.

Make a report on the role of lysins, opsonins, agglutins, and precipitins in disease resistance.

Examine blood clot and serum. Differentiate between serum and plasma. Discuss the production of antibodies in response to foreign substances in the body, the relation to warding off infection, to hives and other allergic manifestations. Study phagocytosis by adding a bit of India ink to a drop of fresh blood.

Discuss the reactions to hot weather which are matters of common knowledge and experience (for example, flushing, thirst, lassitude, perspiration, desire for light clothing) in relation to the maintenance of a stable body temperature. Discuss reactions to cold weather.

Study diagram of human circulation. Note rich supply of blood to certain parts, as digestive tract and brain. Apply correct names to important blood vessels and trace their courses. Ask a student who has had first aid training to demonstrate "pressure points." Relate to direction of flow and to presence of bony structures against which pressure is applied.

To give a basis for a concept of blood in motion and of structure of blood and blood vessels, watch blood circulate in a frog's web (or in gills or tail of salamander tadpole, or in tail of small fish) under microscope or through microprojector.[1] Name corpuscles and plasma. Differentiate blood flow in arteries, veins, and capillaries.

To strengthen concept of continuous movement of blood through their own bodies, have students feel pulse in wrist, front of ear, neck, and knee; listen to heartbeat.

Take pulse and respiration rates before and after exercise. Discuss the ways in which exercise, excessive excitement, and emotional strain modify the condition of the blood, and the results of changes in pulse and respiration rates in counteracting these changes.

Show motion pictures on the passage of materials to and from cells through lymph and blood.

To give a more precise idea of size, shape, and texture of blood vessels, their relation to heart, and distribution, dissect a small mammal. Trace circulation.

Discuss ways in which knowledge of the circulation of the blood has been obtained. Study the social and scientific background for Harvey's discovery of the circulation of the blood and the reasons for the opposition to his theory by his contemporaries. Discuss Harvey's experiments as illustrations of scientific method. Trace the refinements of Harvey's theory as more facts became available with the discovery of the microscope and other scientific advances illustrating the dependence of scientific knowledge upon technical developments.

Demonstrate the gross anatomy of the urinogenital system by means of models or charts. Explain the functions of each of the parts. Indicate the changes that occur in the blood as it goes through the kidneys.

Demonstrate a mammalian kidney with the adrenal gland attached. Procure a thyroid and pancreas and demonstrate them in a similar way. Indicate how these organs regulate metabolism.

Show the effects of adrenalin on circulation by arranging an apparatus for demonstrating the circulation in the web of a frog or the tail of a tadpole, and noting the effect of a drop of adrenalin on the arterioles. Discuss the uses of adrenalin in stopping hemorrhage.

Show films ot the human digestive processes at work. Indicate what changes occur in foods as they pass through the alimentary canal, the mechanical and chemical factors involved, and the manner in which digested foods are absorbed into the blood and lymph: for example, show that the digestive effect of saliva is to turn starch to sugar. Demonstrate that glucose passes through a membrane while starch does not, indicating the pertinence of this fact for human digestion; demonstrate the functions of the gastric juices in changing proteins into chemically simpler peptones and proteoses; demonstrate the digestion of nutrients by pancreatic juices.

Discuss Beaumont's pioneer observations of human digestion. Use his work as an illustration of scientific method.

Demonstrate the process by which the human organism obtains oxygen through respiration. Trace the course of oxygen derived from breathing and show how it is absorbed. Indicate the way in which exercise increases the production of carbon dioxide.

GOOD FOODS AND BAD MEDICINES

The human body, in order to function adequately, must be sustained with adequate energy-giving and nutritious foods. It must not be poisoned by harmful drugs or abused by faulty hygiene. There has accumulated a substantial body of knowledge on good foods and bad medicines that can contribute much to the maintenance of health. However, the consumer's information about foods, drugs, and cosmetics is largely that gained from advertising, which reaches the prodigious dimensions of more than 400 million dollars a year for patent and proprietary medicines alone. It is the function of the following activities to acquaint students with knowledge that will enable them to make correct selections and to reject the spurious.

Choice of Proper Foods

The science of nutrition has emerged from its faddist beginnings into a full-fledged branch of medicine. Discovery of the causes and cures of diseases of malnutrition has made knowledge of diet important not only for the treatment of disease but for the maintenance of health. It is necessary, therefore, to devise activities which will at the same time develop confidence in the new knowledge of human diet and also a healthy skepticism toward the exaggerated claims of advertised products. While stress in these activities is laid on the presentation of positive findings in relation to diet, misconceptions involved in common food fallacies are at the same time combated.

Discuss the fundamentals of good nutrition: the energy foods (starches, fats, and sugars); protein foods (meat, fowl, fish, milk, and cheese, vegetables); minerals (calcium, phosphorus, iron, copper); vitamins. Analyze nutritional requirements and standards for normal individuals at different ages and maturity levels.

Have students keep a record of the foods eaten each day during a five-day period. Determine whether the diet was balanced and whether there was a sufficient quantity of vitamins, calories, and minerals.

By use of posters show the vitamin and mineral content, and the caloric value of common foods in relation to cost.

To illustrate diet deficiency feed white rats or guinea pigs on a diet lacking some essential nutrient or vitamin and compare their growth with those receiving an adequate diet.

Discuss nutritive value of foods as affected by genetic and productive factors, processes, and preparation; effects of milling, sterilizing, freezing, pasteurizing, and drying; methods of preparing and cooking; influence of ageing, storage, and shipping. Evaluate the claims of commercially processed vitamin-enriched foods.

Discuss the problems involved in reducing diets. Collect and analyze advertisements of patent reducing treatments. Plan a week's diet for a person who is overweight and needs to reduce and for one who is underweight and wishes to gain.

Collect and analyze advertisements and literature of food faddists. Appraise the claims of these groups with careful scientific objectivity, to develop in students correct methods of handling controversial issues. Avoid stimulating mere prejudicial rejection on the part of students, yet prepare them to be able to detect fraud; imposture, and falsehood based on ignorance.

Clarify common food fallacies, such as the following: Meats cause high blood pressure, kidney disease, and rheumatism; skimmed milk is valueless; fruit juices are acid foods; eating acid fruits or vegetables and starches together causes indigestion; "acidosis" or "acid in the blood" is caused by eating combinations of bread and meat, fruits and starches, or proteins and starches; acid foods cause "gastric hyperacidity," the symptoms of fatigue, "jitters," and headache; milk and fruit juice taken together will upset the stomach; starches and protein foods are incompatible and should be eaten at distinct and separate meals; only one kind of starch and one kind of protein should be eaten at a time; milk and seafood, lobster and ice cream, pickles and ice cream should not be eaten at the same meal; spinach is rich in iron; roughage foods are necessary for good bowel function; indigestion is caused by "rich" foods; the use of salt may be responsible for Bright's disease, high blood pressure, cancer, and tuberculosis; white meat is less harmful than dark or red meat; raw meat is more healthful than cooked meat; raw eggs are more nutritious or more digestible or more readily assimilated than cooked eggs.[2]

Discuss traditional diets of the various national groups in the United States, indicating the food values of their most popular foods, that is, where they get their requisite vitamins, and what types of food are lacking.

Illustrate the wide divergence of human diet by discussing the foods eaten among the different isolated and primitive peoples of the world, for example, the exclusively meat diet of the Eskimos. Explain adaptations to food resources and to energy demands in various climates. Although these groups survive, available evidence does not prove that their diets are the best possible for them.

Mark locations of fillings and unfilled cavities on diagrams of the tooth arrangement of the upper and lower jaws, or obtain for class use a series of such charts from the school physician or nurse. Discuss the relation of tooth growth and decay to nutrition.

Discuss the findings of the Selective Service Board on the manner in which malnutrition affected the rejection rate of the American military forces.

Discuss the extent and distribution in the United States by region and by income groups of major deficiency diseases such as scurvy, pellegra, beriberi, and rickets. Analyze the degree to which these diseases are controllable if available knowledge were utilized.

Present findings of any studies of malnutrition that have been made in your school, in your community, or in your state. Focus on the fact that malnutrition is not a remote problem, but that every community has wide room for improvement.

Discuss the conquest of famine, the technical developments in agricultural machinery and processes as related to the improvement of the quantity and quality of foods.

Analyze the diets provided in the reformatories, jails, and prisons in your community and state to learn whether they are adequate to prevent deficiency diseases.

Discuss provisions now made against nutritional diseases on long sea voyages. To illustrate early efforts to control nutritional diseases, explain the origin of the term *limeys* as applied to British sailors.

Have students report on the researches of men whose work has been outstanding in the conquest of nutritional diseases, for example, Lind, Goldberger, Elvehjem, Spies.

Utilize references to nutritional diseases which have arisen in other classes, as, for example, in a literature class, the account of scurvy in Dana's *Two Years before the Mast.*

Discuss how the war production program affects the food needs of the civilian population in the United States.

Discuss how the war has increased nutritional diseases of European populations in view of the scarcity of necessary foods.

Test foods for adulterants: milk for coal-tar dyes and formaldehyde; meat for artificial coloring, boric acid, potassium nitrate, starch, and sulfurous acid.

Discuss psychological problems involved in training children for proper food habits; the development of irrational food aversions; ways to avoid them and to recondition such attitudes.

Analyze the causes of food poisoning through food contamination and discuss methods of emergency treatment.

Avoidance of Harmful Drugs

Self-medication without benefit of expert medical guidance involves great hazards. The Federal Pure Food and Drug Act requires that potentially harmful drugs be listed on the labels of the bottles, but it does not fully control the claims made for these drugs and medicines in advertising copy. The consumer therefore requires guidance on the types of drugs that are particularly dangerous to human health and the cautions that are necessary in the use of proprietary drugs and household remedies. The activities proposed here are designed to afford such guidance.

Trace the history of drug therapy from the medicinal herbs used by early man to science of today; the importance of the work of Paracelsus and Sydenham; the beginnings of the replacement of bizarre medication by systematic pharmacology; the importance of the influence of botany and chemistry upon the scientific use of drugs; the period of pharmacological nihilism when all drugs were suspect; the advent of synthetic drugs; the development of experimental pharmacology; the establishment of the values of specifics; the discovery of arsphenamine, prontosil, the sulfa compounds, penicillin, and other agents, which open up new vistas of successful drug therapeutics. Explain how the harmfulness of certain drugs is proved.

Discuss the importance of consulting a physician before using drugs; the dangers of taking medicines because they cured other family members or neighbors; the hazards of following the advice of druggists.

Tabulate the indispensable contents of an average household medicine chest and explain the uses of each item.

Acquaint the class with the publications of consumers' groups, the Council of Pharmacy and Chemistry and the Bureau of Information of the American Medical Association, and the Federal Trade Commission that expose false and misleading claims of drug and patent medicine manufacturers.

Explain the dangers of acetanilid, acetphenetidine, and antipyrine as pain killers; note that the Federal Pure Food and Drug Act requires that preparations containing these drugs must have a statement indicating their presence; underscore in this way the importance of reading the labels of drug preparations and interpreting their meaning; show the misleading and sometimes fraudulent claims for these preparations in radio and newspaper advertising.

Discuss the limited usefulness of liniments, rubbing salves, and plasters for the relief of painful muscles. Show misleading claims and excessively irritant effects of many of the widely advertised patented products.

Review critically the claims of advertised remedies for colds: pills, nose drops, jellies, inhalants, mouthwashes, ointments, alkalizers.

Discuss the dangers of treating a cough with "cough medicines." Indicate the need for medical advice concerning a lingering cough to avoid the development of serious complications.

Show the fallacies involved in the use of "disinfectant" mouthwashes for "halitosis," indicating the diverse causes of bad breath and the ways to treat them.

Discuss the misconceptions concerning constipation that lead many people to utilize laxatives and cathartics unnecessarily; indicate the hazards of taking laxatives that are irritating to the intestines, and colon; analyze the excessive and misleading claims of patent remedies for constipation.

Analyze the errors involved in the widespread belief in "acidosis" and the values of alkalizers.

Review critically the claims of advertised remedies for "indigestion."

Discuss the use of sedative drugs, such as the bromides and the so-called hypnotic drugs (barbituric acid and its derivatives). Indicate that because of the dangers of bromide intoxication involved in their use, any proprietary preparations containing bromides must indicate this fact on their labels. Interpret the significance of the fact that in the case of barbituric acid and its derivatives the additional statement must be printed on the label, "Warning—May Be Habit Forming."

Analyze the advertised claims of the potions and elixirs, pills and tablets, yeast cakes and prepared foods that are on the market as "tonics" for poor appetite, insomnia, anemia, fatigue, and a host of other ailments.

Discuss the harmful effects of morphine, cocaine, hashish (marijuana), and other such habit-forming drugs whose sale is closely regulated.

Discuss experimental findings on the effects of alcohol in small and large doses on coordination and on muscular performance. Indicate the difficulty in arriving at scientific judgments in this field because of propaganda and the moral and ethical overtones that have come to be associated with the question. Test the methods and findings of recent studies in this field to learn whether they are valid as scientific documents.[3]

Present conflicting claims concerning the dangers of tobacco; the relative amounts of nicotine in cigarettes, cigars, and pipe tobacco.

Explain the dangers of patent medicines sold to cure arthritis which contain cinchophen or atophan, and the restriction of their use by the Federal Pure Food and Drug Act.

Analyze cosmetic creams, astringents, and face lotions.

Discuss dangers of hair-removing preparations, especially those that contain an alkaline sulfide.

Analyze claims of cures for baldness and dandruff.

Indicate hazards of "pimple pills" and "blood purifiers" that contain potassium iodide.

Discuss the claims of the patent medicines for kidney and bladder trouble, for diabetes, for goiter, for cancer.

Analyze the special types of appeal used by advertisers of patent medicines, such as the play upon personal insecurity, the craving for beauty and appeal to the opposite sex, and popular symbols of pride and prestige. Illustrate the use of devices of suggestion to avoid clear statement of claims and so to elude prosecution for fraud. Have students keep notes of flagrant types of misrepresentation; mount advertisements on bulletin boards with critical comment.

MEDICAL CARE

When to consult a physician, what type of physician to consult, how to cooperate with the doctor and to understand his procedures are immediate and practical questions which the following activities are framed to help answer. In the background of all these questions lie the significant problems of the availability of medical services. These have been agitating America particularly since the findings of the National Health Survey have indicated the inadequacy of medical care available to members of the lower income groups and to the rural population. The activities offered in this field will enable students to appraise the health resources of their communities and guide efforts toward their improvement.

Consulting a Physician

The need for expert guidance in medical care is a corollary of the dangers of self-medication by drugs and patent medicines. When to call a physician requires discussion because preventive medicine is so recent that it is still the general and hazardous practice to delay calling for medical care until the patient is "really ill." On the other hand, there are many ways in which the layman can facilitate the work of the physician—through first aid care, proper caution in matters of health and good morale when sick. [4] The drain upon the medical profession because of the needs of military forces and the problems of the civilian population in time of war underscore the importance of this phase of health education.

Discuss the need for early consultation with a physician in time of ill health even in the case of such illnesses as have been traditionally regarded as inconsequential; the need for periodic health examinations; and the need for a follow-up of the doctor's findings.

Review what to do in emergencies, that is, the use of first-aid methods, such as measures for stopping bleeding from wounds; use of the thermometer; methods of artificial respiration. In each instance interpret why, as well as how, a method is used.

Set up criteria by which the competence of a physician can be measured—the length and character of his medical training, his internship, his hospital association, his specialty. Indicate the difficulties involved in such appraisal and the need for more guidance to the consumer of medical care by the medical profession itself.

Understanding of the Procedures of Physicians

There is considerable room for improvement in patient-doctor relationships. Misunderstanding arises out of the failure of the layman to understand the purpose of much of what happens to him in doctors' offices. He does not as a rule know the uses of the doctor's instruments, the reasons for the tests to which he is submitted, and the theory and practices underlying the doctor's advice and treatment. Such ignorance breeds mistrust and fear. Activities are here suggested to dissipate the basis of this unsatisfactory relationship by conveying knowledge of instruments and of theories of medical care that are readily understandable to laymen.

Demonstrate the uses of the stethoscope, fluoroscope, ophthalmoscope, otoscope, and other instruments in the doctor's office in such a way that when the student consults a physician the significance of these tools will not be obscure. Unless the teacher is specially trained, it may be necessary to have a physician or nurse handle this and some of the following demonstrations. The teacher will be able to follow up the technical demonstration by discussion of the interpretations of the findings.

Explain reasons and significance of routine tests made in a physician's office; hemoglobin determination (indicate the normal variability of blood counts; discuss findings in terms of the oxygen-carrying power of the red cells; relate white cell count to presence or absence of infections; interpret causes of changes in blood count); blood pressure determination (find normal variability for different sexes and different ages; relate to efficiency of blood in carrying materials over the whole body); a basal metabolism determination (relate the heat production in the body, to carbon dioxide-oxygen ratio); urinalysis (relate findings to composition of blood and maintenance of normal composition and concentration; discuss normal individual variability and need for more than one test for basis of a diagnosis).

Discuss the significance of the typing of blood used in blood transfusions. Indicate relevance of the discussion to the Red Cross blood bank. Explain why it is not necessary scientifically to separate Negro and white blood in the blood bank. Discuss reasons for this separation.

Discuss the importance and uses of vitamin K in preventing hemorrhages, and particularly in lowering the infant death rate.

Explain the functioning of the electrocardiograph. Show the major types of heart diseases.

Visit an X-ray laboratory and note how plates are taken and interpreted.

Discuss the use of radium and radioactive substances in modern medicine. Explain the use of "tagged atoms" for experimental work.

Discuss the uses of infrared rays, diathermy, and ultraviolet rays in medical treatment.

Discuss the values and uses of different types of anesthetics in surgery.

Give the students a summary understanding of what is known about some of the more prevalent functional diseases, which they may have encountered through the illnesses of members of their families: for example, duodenal and stomach ulcers; gallstones and diseases of the gall bladder; kidney diseases; colitis; arthritis; cancer; glandular disorders; mental disorders.

Discuss the widely held misconception that "growing pains" are inevitable.

Prepare tabular review of present knowledge of important communicable diseases, listing the name of the disease; the germ which is the causative agent, if it is known; the source of infection; the agent and mode of transmission; whether a method of laboratory recognition is available; whether a method of active immunization is practiced; and whether there are special methods of control. Explain incubation days, periods of greater communicability, and usual length of quarantine or isolation.[5]

Demonstrate by prepared slides and by illustrative posters the criteria by which a physician identifies the different types of disease-causing microorganisms: the *cocci* (pneumococci, gonococci, staphylococci, and streptococci); the *bacilli* (anthrax, tetanus, typhoid, diphtheria, dysentery, tuberculosis); the *spirilla* (relapsing fever); *spirochetes* (syphilis); the *protozoa* (amebic dysentery, malaria, trypanosomes that cause African sleeping sickness); the *fungi* (athletes foot).

Discuss the manner in which physicians identify the diseases caused by filterable viruses (for example, smallpox, chicken pox, measles, German measles, yellow fever, trachoma, infantile paralysis, mumps) to illustrate physicians' techniques of diagnosis.

Describe the effects of the ultramicroscope and of powerful centrifuges on virus researches.

Illustrate methods of making cultures of bacteria to indicate the manner in which laboratories assist in the diagnosis and treatment of diseases. (Do not handle living pathogenic bacteria. The use of nonpathogenic forms is adequate to serve the purposes of the demonstration.)

Discuss insects and other animals as disease transmitters. Illustrate adaptations and habits of rats, ground squirrels, head lice, body lice, tsetse flies, mosquitoes, and other disease carriers as they relate to disease transmission and control.

Prepare reports on the life cycles of pathogenic protozoa: of the tapeworm, trichina worm, and hookworm and their bearing on disease transmission and control.

Discuss ways in which personal cleanliness is related to disease transmission. Explain need for antiseptic precautions. Describe purpose and methods of achieving asepsis. Evaluate the effectiveness of different types of disinfectants.

Explain each step of the process of smallpox immunization and its effects.

Have the Dick test for scarlet fever and the Schick test for diphtheria demonstrated. Explain antigenic reactions.

Demonstrate the use of serums for treatment of allergies and explain principles involved.

Discuss our knowledge and ignorance about colds, influenza, and grippe, their causes, most effective treatment, and means of prevention.

Describe recent medical advances in the treatment of gonorrhea and syphilis.

Describe the treatment of tuberculosis by pneumothorax and by the Rollier sun-bathing system. Stress the need for early diagnosis, proper working and living conditions, rest, and adequate and nutritious food.

Show motion pictures containing sequences relating to communicable diseases, such as "Life of Louis Pasteur," "Yellow Jack," "Prisoner of Shark Island," and "Jezebel." Discuss these in class, emphasizing what was learned concerning the nature of the diseases and their effect on the people involved.

Have classroom reports on such books as De Kruif's *Why Keep Them Alive?*

Listen to radio programs pertaining to communicable diseases and use them as a basis for classroom discussion.

Make reports on the life and work of Louis Pasteur, noting in particular his methods of working out problems; on Walter Reed and yellow fever, emphasizing his methods of defining and attacking the problem; on Edward Jenner and vaccination; on Koch's work and its importance to scientific thinking about germ diseases; on Trudeau and tuberculosis; on Rollier.

Discuss reasons for vigorous opposition to Jenner, Pasteur, and the germ theory of disease.[6]

Collect clippings about new discoveries of causes or identification of communicable diseases. Report on these, or place on bulletin boards, or classify and place in a scrapbook with personal comments.

Appraising the Medical Resources in the Community

Increased recognition of the achievements of the medical profession is leading more people to seek medical care than ever before in history. At the same time, the new scientific methods of diagnosis and of therapy require tests and instruments that have increased the costs of medical services considerably. As a result, problems have arisen which are associated not with the scientific competence of physicians but with the distribution of medical services within the price range of the consumer. When adequate medical resources and hospital facilities are absent illness and death rates are high. There is wide disparity in the distribution of medical services in different income groups within communities and between rural and urban regions largely for financial rather than scientific reasons. The activities proposed here are patterned to give knowledge and understanding of this situation and to suggest possible solutions. They may also offer materials for the vocational guidance of students.

Investigate the health resources of your community: the number, training and specialties of physicians and surgeons; the hospitals, clinics, and sanatoria—their facilities, staff, and financial backing, number of private registered nurses and public health nurses. Compare findings with available information on conditions elsewhere.

Report on available studies on the medical profession: length and type of training and internship, cost of training and of setting up office, problems of securing practice and of hospital affiliation, and average incomes. Ask a local physician to speak to the class on these problems as a physician sees them. Consult medical school catalogues for requirements for entrance and graduation. Discuss the methods of certification by the examining boards of various medical specialties.[7]

Study your state laws regulating the licensing of a physician. Discuss the extent to which they protect the community as compared with the laws of other states. Note particularly whether a basic science certificate and internship are required.

Ask the school nurse to discuss length and type of training, duties, conditions of work and earnings of nurses. Study laws concerning nurses; consult catalogues on nurses' schools.

Discuss the functions and training of pharmacologists, of clinical laboratory technicians, of physical therapy technicians, of occupational therapists, of public health workers, of optometrists, of dentists, of hospital social workers, and others whose work relates to maintaining the health of the community.

Collect data on osteopaths, chiropractors, midwives, and other persons dealing with health in your community. Note length of their training as compared with that of physicians and surgeons.

Have your students keep a record over a considerable period of the money spent by their families on medical care. List costs for any type of medical services including costs of all medicines and household remedies. Compare findings with those of the U. S. Department of Labor Study of Consumer Purchases.[8]

Obtain information on the history of local hospitals to show the increasing importance of hospitals in medical care. Analyze reasons for this recent development.

Analyze reasons for high costs of medical care in terms of the development of modern medicine and its need for laboratory tests, x-rays, and hospitalization.

Investigate to what extent adequate medical care is within the cost range of the lower and middle income groups in your community.

Discuss the functioning of group health and hospital plans in your community. Analyze the features of proposed group health plans and those functioning in other communities. Obtain information on the stand taken on group health plans by the American Medical Association and the Committee on Research in Medical Economics and evaluate them.

Visit a local dispensary or clinic to observe treatment given patients.

Visit the local public health laboratory and have its work explained.

Visit a hospital and go through its laboratory, x-ray rooms, operating rooms, and wards. Observe methods used to obtain asepsis and learn about precautions taken in isolation ward to prevent spread of communicable diseases.

Investigate health insurance costs, using sample policies of several companies. Compare these for such features as rates and protection offered. Obtain information on what clauses in a policy are most desirable.

Appraise the plans being discussed in relation to extension of Federal aid to health as an aspect of the Social Security program. Study present aid given to local and state health agencies by the Federal government.

Find out how much of the local community chest fund is allotted to combating communicable and other diseases among indigent families. Try to relate the existing situation to the apparent needs.

Study the work of social agencies and organizations in your community concerned directly or indirectly with health: for example, the Red Cross, the local branch of the National Tuberculosis Association, agencies working with nutrition and syphilis. Study personnel, methods and scope of work, financing, and clientele.

Discuss the organization of health services in the military forces, that is, the manner in which the youth of the United States are provided with medical care in the training camps and in the field.

Discuss the volunteer health programs under way in your community stimulated by the need for protection and improvement of the health of the civilian population in wartime, for example, local activities arising out of the national nutrition program.

ROLE OF THE COMMUNITY IN HEALTH

The maintenance of human health is not only a personal matter but also a community responsibility. An individual's habits of health and hygiene may be excellent, his choice of foods proper, his behavior in the use of drugs and medicines intelligent, and his attitude and practices toward medical science and the physician's role in medical care enlightened. Yet this will not be sufficient to maintain him in good health and to protect him from disease. There are many factors in health and disease over which the individual has little control and for which he must depend upon the community for his protection. Community protection of the water and food supplies from contamination, proper sewage, measures to prevent and check the spread of communicable diseases by immunization and isolation, factory and mine safety and health legislation, health provisions in housing laws, are all impotant factors in determining the health of the people of any community. The extent to which the community has and enforces public health laws depends largely on the alertness to the need for such protection on the part of the people who make up the community. An understanding by students of the health problems of the community and of measures and resources of meeting them will help make them active participants in this important phase of community life.

Discuss provisions existing in the community for safe water and milk, pure food, sanitation, and sewage and industrial waste disposal; quarantine; mosquito and fly control; rodent control; facilities for immunization against communicable diseases; precautions against the spread of hookworm and amebic dysentery, undulant fever, trichinosis, typhoid, and other food, water, or milk-borne diseases; control of dusts and fumes; procedures of recording vital statistics; methods of regulating standards of vaccines and antitoxins.

Analyze laws relating to public health services in your community as compared with other communities. Suggest changes and additions in them that would increase their effectiveness. Investigate the degree to which they are enforced.

Look up the tax rate for health services in your community as compared with other communities. Analyze the manner in which the money is allocated and expended. Draw up a proposed budget for adequate health services and determine the tax rate required to finance it.

Discuss laws and practices in your community relating to occupational diseases and accidents; safety codes, factory and mine inspection regulations, and workmen's compensation laws. Find out the accident and occupational disease rates and study how they can be lowered.

Discuss health aspects of housing laws as they related to safety, sanitation, ventilation, and congestion. Make a survey of different neighborhoods in your community to determine the extent to which they are enforced. Note special health problems of slum areas.

Discuss efforts to control malaria by the draining of marshes. Evaluate success of such a program in your community.

Investigate the kind of communicable diseases which have occurred in your community during a three-, five-, or ten-year period, learning the number of cases of each disease and resulting deaths each year. Compare the rates of illness and death in your community by age, race, national groups, income groups, and sex with those of similar groups in the state and nation. Study trends and reasons for existing differential rates. Explain the different bases on which illness and death rates are computed and illustrate the reasons for their use.

Prepare spot maps of the community, showing the distribution of communicable diseases. If the town is sharply divided on an economic basis, see whether there is any correlation between incidence of diseases and low- and high-income neighborhoods of the community. Do the same for neighborhoods in which specific races and national groups predominate. Analyze causes for the fact that higher rates are usual among Negro groups. Prepare maps of the state showing the distribution of various communicable diseases by counties. Compare rural sections of the state with urban areas.

Make a map of the facilities provided in your community for public parks and other recreational facilities and discuss the extent to which they meet needs for health, particularly in congested areas.

Visit a dairy to observe scientific pasteurization and handling of milk; note reasons for pasteurization and for precautions in handling milk. Discuss regulations on ice cream manufacture and storage.

Visit the local water supply plant to observe steps in the purification of water. Invite a bacteriologist to explain chemical and bacteriological tests performed.

Visit garbage-disposal and rubbish-disposal plants. If the community does not have modern facilities of this type, visit "dumps" and study these as factors in the spread of communicable diseases.

Discuss syphilis control in your state and community in terms of methods of reporting and following up cases; the availability of treatment to those who cannot afford to pay; access to free laboratory service for blood tests; supply of antisyphilitic drugs to physicians and clinics; blood tests for expectant mothers; blood tests before marriage; the educational program.

Study regulations requiring physicians to register specific diseases in the local health department; explain the necessity for these rules. Discuss the procedure of reporting births and deaths in your community.

Investigate ordinances pertaining to licensing and muzzling dogs, and discuss why such measures are desirable. Report on the development and use of the Pasteur treatment against rabies.

Interpret the local laws for the control of hay fever by the eradication of ragweed. Have students participate in enforcement of these laws.

Study the decline in infant and child mortality in your community and throughout the country over a period of years by income groups, race, and nationality. Show achievements and tasks ahead.

Collect data by photography and interviews of nonenforcement of existing health laws and of the need for new laws to improve the health standards of your community.

Study the provisions made by the board of education for the prevention and control of communicable diseases among school children; study the rules of absences because of ill health and the care with which they are enforced.

Have the students make sanitary surveys of the school building. Such a study should include the cleaning methods used and their relative effectiveness. Inspect classrooms, halls, stairs, and lavatories; note hand-washing facilities in lavatories; include locker rooms, showers, and swimming pools.

Study the sanitation of food-handling, dishwashing, and general cleaning methods used in the school cafeteria.

Look up laws relating to school ventilation systems and determine whether they are based on the most recent scientific principles of ventilation.

Discuss the Federal Pure Food and Drug Act in relation to specific drugs which are considered harmful. Illustrate the degree of effectiveness of this law by indicating what has happened since it was passed.

Discuss local regulations regarding the sale of alcohol and tobacco to children.

Propagandize the community by exhibit of charts, graphs, photographs, clippings; by plays, debates, symposia, letters to editors of local newspapers, and relegations to local authorities, on solutions to problems of community health which your students have revealed.

Report on the work of the United States Public Health Service and other Federal agencies engaged in health work, such as the Farm Security Administration on rural health and the Women's Bureau on maternity care. Determine the extent to which your community benefits from their work.

Report on the organization and work of local and state boards of health.

Study graphs or charts to show the comparative incidence of smallpox in California since the repeal of the compulsory vaccination law; and in some other state that has maintained compulsory vaccination over the same period of time.

Discuss the causes of opposition to public health regulations.

Discuss the meaning of public health regulations as they are related to political philosophies of individualism and social responsibility.

Prepare maps showing the distribution of diseases by states from the United States Public Health Service and interpret them.

On a world map, mark areas where diseases such as cholera, yellow fever, and plague are common. Account for the prevalence of these diseases in some countries and for their relative absence in others.

Report on the relation of health conditions in other countries to health conditions in the United States; for example, the importation of infected malarial mosquitoes from Africa into South America. Discuss agencies involved in checking the spread of epidemics from one country to another and the methods used.

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THE EDUCATIONAL AND PROFESSIONAL STATUS OF SCIENCE TEACHERS IN THE PUBLIC SCHOOLS OF COLORADO

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THE object of this study was to determine the status of junior and senior high school science teachers in the public schools of Colorado. The investigation included both full- and part-time science teachers and covered such data as the size of the school in which they taught, science teaching combinations, subjects taught outside the field of science, undergraduate majors, professional training, and the degrees held.

The data for the study were obtained during the school year 1941–1942. Work connected with the war effort and other duties have delayed publication. However, the writers believe that a similar study, made as soon after the war as school conditions become normal, would duplicate this one in all essential respects.

The questionnaire method was used. A carefully formulated two-page printed blank was sent to teachers in all Colorado cities, towns, and villages. Altogether 449 questionnaires were sent out. By pursuing the usual follow-up techniques, returns sufficiently complete to be used were obtained from 263 teachers. That was 59 per cent of the total original list. These 263 responses represented 228 different high schools, including practically all the schools in the state with an enrollment large enough to be of real significance in the study.

Table I shows the classification of these schools on the basis of pupil attendance.

The relatively sparsely settled conditions of Colorado is disclosed by the fact that 62.28 per cent of the high schools from which returns were secured had 200 pupils

TABLE I

CLASSIFICATION OF 228 HIGH SCHOOLS IN COLORADO WITH RESPECT TO PUPIL ENROLLMENT

No. of Pupils Enrolled in the High School	*School Frequency In Each Enrollment Group*	*Per cent of Total*
1- 100	101	44.30
101- 200	41	17.98
201- 300	36	15.79
301- 400	14	6.14
401- 500	6	2.63
501-1000	14	6.14
1001-2000	12	5.27
2001-plus	4	1.75

or less enrolled and but 13.16 per cent had an enrollment of more than 500.

The term *science* in this study was used with a broad connotation and included any subject which may be included under natural science headings, such biological science, chemistry, physics, and general science. Even in this inclusive sense the data reveal that the percentage of teachers who teach but one science is very low. Table II shows that of the 253 teachers reporting on this item but 11.07 per cent taught biology, 7.11 per cent chemistry, and 6.72 per cent physics, exclusively. In other words slightly less than 25 per cent of the science teachers in the state had a program in which they taught but one of the special sciences. As would be expected, the responses showed that these specialized teachers were limited to schools in the larger cities.

TABLE II

SCIENCE TEACHING COMBINATIONS OF 253 FULL- AND PART-TIME SCIENCE TEACHERS IN COLORADO

Subjects Taught	*No. of Teachers*	*Per cent of Total*
Biology (only)	28	11.07
Chemistry (only)	18	7.11
Physics (only)	17	6.72
General Science (only)......	52	20.55
Two sciences (various combinations)..............	78	30.83
Three or more sciences (various combinations)	60	23.71

Since the content of General Science cuts across several specialized fields, it cannot be considered to fall logically into the "one science" category. It probably would have been more appropriate to place it under the "three or more sciences" heading. If this were done the results would show that 74.49 per cent of the science teachers in the state taught two or more science subjects.

In the two-science combinations the subject of biology was most often paired with general science for a percentage of 6.28. Chemistry stood next in the teaching combination with biology at a percentage of 3.53.

Chemistry, like biology, in the two-science teaching combination was most frequently paired with general science. Here the percentage was 7.45. Its next most frequent combination was with physics for a percentage of but 3.53.

Individuals outside the larger high schools who designated themselves as physics teachers apparently were required to adjust themselves to an especially varied teaching program. There were no two-science combinations listed with physics as the leader. In the three-science combination physics stood with biology and chemistry most frequently. But even here the frequency was very low with a percentage of but 1.57. The physics, biology, chemistry, and general science grouping was found to have the same percentage. Whether the war with its emphasis on aviation and other types of mechanized combat has changed the picture and given greater emphasis to physics we have no way of knowing. We suspect that it has. Even if true, only the future can reveal whether that shift will be a permanent one.

It was also found that natural science teachers were frequently required to teach subjects outside the field of science even in the broad sense that we have defined it. Table III shows in ranked order all these subjects which had a percentage frequency of more than 5 per cent. The highest frequency was found for mathematics, as might have logically been expected; physi-

TABLE III

THE LEADING SUBJECTS OUTSIDE THE FIELD OF THE NATURAL SCIENCE WHICH FORMED TEACHING COMBINATIONS WITH THESE SCIENCES

Subject	*Number of Teachers Reporting Each Combination*	*Per cent of Total Combinations*
Mathematics.	106	30.72
Physical Education. .	59	17.10
History	20	5.80
English.	19	5.51
Industrial Arts	19	5.51

cal education stood next with a percentage value of but little more than one-half as great. History, English, and industrial arts stood next and trailed off in that order but with a much lower frequency. Other combinations with still lower percentages covered a very wide range of subjects. Commercial branches appeared (4.35 per cent); shop (3.77 per cent); and music (3.48 per cent). Twenty-six other subject combinations, such as general education, agriculture, home economics, and social science, ranked still lower.

The amount of science education which 252 full- and part-time science teachers had acquired in preparation for their work also presented an interesting picture. The results for the 174 teachers with the most training are shown in Table IV. One hundred seventy-four teachers, or 69.04 per cent, had earned more than fifty quarter-hours credit in science, while 78, or 30.95 per cent, had less than fifty quarter-hours credit. The two part-time teachers lowest in this respect had less than ten quarter-

TABLE IV

NUMBER OF QUARTER-HOURS CREDIT IN SCIENCE EARNED BY THE 174 FULL- AND PART-TIME SCIENCE TEACHERS IN COLORADO WITH THE MOST TRAINING IN SCIENCE

No. of Quarter-Hours	*No. of Teachers*
More than 100.	63
91–100.	18
81–90.	18
71–80.	26
61–70.	25
51–60.	24

hours each. Considering the wide spread of science subjects taught, this preparation for the group as a whole can not be said to be adequate. Especially is this true since the teachers who had earned the most science credit were the one-subject teachers in the larger systems.

Two hundred thirty-nine full- and part-time science teachers indicated their undergraduate majors. Seventy-one of this group had majored in more than one field. The results by subject are shown in Table V. The figures show chemistry to be in the lead with the biological sciences, mathematics, physics, and unspecialized science following in that order. The individuals who majored in other subjects, such as education, agriculture, physical education, and social studies may have been part-time science teachers.

TABLE V

THE MOSE FREQUENT UNDERGRADUATE MAJORS TAKEN BY 239 FULL- AND PART-TIME SCIENCE TEACHERS IN COLORADO

Subject	*Frequency*	*Per cent*
Chemistry.	69	28.87
Biological Science (Biology, Botany, Zoology) . .	60	25.10
Mathematics	52	21.76
Physics	28	11.71
Science (Without further specific designation).	28	11.71
Education	19	7.95
Agriculture.	8	3.35
Physical Education	8	3.35
Social Studies	7	2.93

Thirteen other subjects, such as English, home economics, industrial arts, and psychology also appeared with still lower percentages.

The *professional* courses taken by the 252 full- and part-time natural-science teachers in the state who responded to this item revealed that the great majority of them had taken training in *how* to teach as well as *what* to teach. Table VI presents the data for the thirteen professional courses taken with the highest frequencies. It is rather gratifying to find that the subjects taken most frequently were educational psychology and student teaching;

for these areas, when properly taught or administered, are certainly among the most valuable for a prospective teacher.

TABLE VI

THE THIRTEEN PROFESSIONAL COURSES TAKEN WITH THE GREATEST FREQUENCY BY 252 FULL- AND PART-TIME NATURAL-SCIENCE TEACHERS IN COLORADO

Professional Subjects	*Numerical Frequency*	*Per cent*
Educational Psychology....	232	92.06
Student Teaching	222	88.10
Secondary Education	175	69.44
History of Education.......	173	68.65
Philosophy of Education....	154	61.11
Methods of Teaching Science	152	60.32
Tests and Measurements....	151	59.92
Educational Administration	131	51.98
Child Psychology	99	39.29
Curriculum Construction...	83	32.94
Teaching of Special Subjects	82	32.54
Guidance	69	27.38
Psychology of Special Subjects..................	50	19.84

In regard to academic degrees, of the 261 full- and part-time science teachers who reported on this item, all but two had their bachelor's degree. Of these two, one was a superintendent and the other a teacher in high schools with fewer than fifty pupils enrolled. The bachelor's degree then, was held by 99.22 per cent of the teachers. Of this group 86, or 32.95 per cent, held their master's degree. Many others had taken some graduate work.

In conclusion, this study indicates that the science teachers of the state taken as a whole have had considerable training for their work both professionally and academically. In individual cases, however, particularly in the smaller high schools, this training was decidedly inadequate. In respect to teaching load it seemed that science teachers frequently were called upon to handle an undesirably wide range of subjects; but this seems to be the tendency throughout most of the country. The Preliminary Report of the Cooperative Committee on Science Teaching consisting of representatives from the American Association of Physics Teachers, the American Chemical Society, the Mathematical Association of America, the Union of American Biological Societies and the National Association for Research in Science Teaching found, as would be expected, the chief problem in this respect to exist in connection with the smaller high schools of the country. This committee states that a beginning teacher in a small school nearly always must teach at least three different subjects, and often four or five. Because of this fact the Cooperative Committee recommended that "approximately one-half of the prospective teacher's four-year college program be devoted to courses in the sciences"; and further that, "half of the college program be devoted to courses . . . divided among three sciences. . . ." [1] Our study shows the importance of these recommendations as made by the Cooperative Committee and we hope that findings such as these will influence practice in the education of science teachers both towards an adequate number of hours and a sufficiently wide distribution of those hours in the field of science.

REFERENCE

1. "The Preparation of Science Teachers." *School Science and Mathematics,* 42:639, 1942.

EXPLANATIONS OF NATURAL PHENOMENA BY ADULTS

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Several years ago I was first introduced to Jean Piaget, through reading his books, *Child's Conception of the World* and *Child's Conception of Physical Causality*. It was an interesting meeting and a challenging one. His theses—(1) that the child develops mentally in steps or "stages" and (2) that thus the thinking of the child is different in kind from that of an adult—made me wonder; in fact, set me off on some investigations along these lines. [11] *

How do adults explain occurrences with which they are not familiar? Is there any real difference between their explanations and those by children?

Evidence was gathered by showing seven simple demonstration-experiments to 35 members of the faculty of a liberal arts college, and asking them for prediction of what would happen and for explanation of the phenomenon. Those who cooperated were members of departments other than the natural sciences: speech, languages, arts, social sciences, physical education, and the library; 18 of them held doctor's degrees, 17 the master's. Eight of them held professorial rank (assistant, associate, or full professor); 14 were instructors; 12 were tutors; and one, the rank of fellow. None of the subjects of this study had majored in his undergraduate or graduate preparation in any of the natural sciences, although all except two had studied some science course in college and all but one, some science in high school; three had taken science courses during graduate study: two of these studied the anatomy and physiology of the nervous system in connection with a major in speech; the other, neurology in connection with work in physical education.

The subjects came singly to a room in the science building, and sat at a small table facing the investigator during the interview, which averaged 45 minutes. The interview began with the following statement, "I am interested in a study as to how people make explanations. You can help by answering some questions and your cooperation will be greatly appreciated. The questions are based on seven simple demonstration-experiments which I shall present in turn. In each, I shall show you the set-up of apparatus; briefly state the procedure; then ask you what will happen, and second, how you account for what will happen."

At the beginning of each, the subject was asked whether it was familiar to him. After he had made his prediction and given his explanation of it, the demonstration was performed; whereupon the subject was asked what he had seen and how he would account for the occurrence. All responses and comments were recorded by the investigator.

With very minor exceptions, the subjects were cordial and cooperative. One felt somewhat resentful that it had not simply been called a physics test, in which event, she would not have participated. Two or three seemed rather nervous and ill at ease. Several inquired as to the nature of the investigation and one or two offered suggestions concerning it. Certain aspects of these and other comments are summarized later in this report.

* Because of the length of Dr. Oakes' paper, it is appearing in two parts. The bibliography is at the end of the second part of the article, and will be printed in the next issue of the journal.

* Oakes, Mervin E. *Children's Explanations of Natural Phenomena.* Bureau of Publications, Teachers College, Columbia University. In press (1945).

Numbers in brackets in this paper refer to items in the bibliography at the end of the second section, which is to appear in the October issue of this journal.

DEMONSTRATION NO. 1: TWO SHEETS OF PAPER

This item is quite similar to one used by Zawerska, [14] who credits its use to Muchow of Hamburg. The investigator's words are quoted.

"I have here a pad of scratch paper 3" x 5"; if I take two sheets [investigator holds one in each hand], crumple one; then drop them both at the same instant—how will they fall to the floor?"

The explanations of predictions include such terms as "air resistance," "more mass per area," "density of what surface there is," "flat surface acts like wings," "like streamlining a car," "flat piece is supported—I don't know—I think it has to do with air pressure," and the like.

Thirty-one subjects predicted correctly; one merely stated that the "unfolded one will be deflected by currents of air"; three that "they'll fall at the same rate." One of these added, "Bodies of same weight fall at same speed—didn't somebody do an experiment from the Leaning Tower of Pisa on that?"

Some of them tend to introduce provisory and explanatory material into their predictions. In fact, the reasoning or explanation frequently precedes predicting. Examples: Two who predicted more rapid fall stated, "If in a vacuum, they would fall at the same rate." One, "Well, they're supposed to fall together, but the ball (wad) will fall first." Two used the words, "should" and "ought to" fall faster. Another, "If there were no currents of air, they would reach the table at the same time; if there were, the flat one will float." Note lack of discrimination between "currents" and resistance of air. Another, "Greater chance that crumpled one will fall in a straight line due to resistance of air; unfolded sheet will go slower due to greater surface and is less likely to fall directly beneath." Others use expressions of caution or hesitation: "Most likely"; "I should think"; "One would normally expect"; "I'm probably wrong, but I think"; and the like.

When the sheets were dropped, one said, "It didn't flutter as much as I thought it would"; five, "I was right that time." Of the three who predicted incorrectly, two said, "I was wrong"; the other, "Obviously the crumpled one fell faster."

In further explanation after the observation, 24 made no change from that given with their prediction. Two introduce "air currents" to account for the slower fall of the unfolded sheet. One said, "Air is canalized into the crumples" of the wadded sheet; another, "Air is caught up in the crevices and makes it heavier—not the weight of the paper itself." Of those who predicted equal fall, two also referred to "air currents."

DEMONSTRATION NO. 2: SHEET OF PAPER ON BOXES

This set-up was suggested by a member of the Physics Department.

"I have here two wooden [chalk] boxes and a sheet of typewriter paper. If I place the paper on top of the boxes [placed 6 inches apart at center of table] and blow across under it [pointing along table top], what will happen?"

Predictions here varied considerably. One subject even said, "I'd say it's unpredictable; but I expect to paper to rise and shift to one side—anything won't surprise me—I'll say it's just the way the blow went." Ten said in effect, "Nothing will happen" or "ought to happen"; nine, "The paper will flutter"; nine, "It will blow off" or "toward me" (i.e., away from source of blowing); eight, "It will rise"; one, merely, "It will move." In a few instances, the statement of an individual is tallied in more than one of the totals given above. For instance, "It depends on how hard you blow and how good your aim: if you blow hard enough, paper would wiggle or blow off; if you blow next to table, nothing will happen." Altogether seven, as the one just quoted, stipulated, "it depends on how hard you blow." One added, "Of course, now it's going to be different; it's a guess, really." Another, "It might happen that the paper will rise and fall or it might be lifted off the boxes and blown toward me." One, "It will either go up or down: because of rebound of air current, paper will fly up or, due to vacuum beneath, paper will collapse between boxes." ["Which?"] "The second unless you blow too high."

Only three predicted correctly, "It will go down."

In explaining these predictions, the subjects refer to "vacuum beneath," "pressure would be dissipated," "air current spreads out," "the force of the air," "friction of the air," "breath is warmer," "you're disturbing the stillness of the air," among others. One statement implies animism or personification, "The air will be dispersed before it attempts to go up." Others said: "A breeze doesn't go in a straight line; it circulates [waving arms]." "You're forcing air beneath and it's bound to lift up." "I think that breath emerges in an expanding—like a funnel—so that its far edge will move the paper." "I don't know, but I think you displace air: like air currents under an airplane [moving hands up and down alternately]." "I don't know; I can't account—I really can't give an explanation."

This set-up gives a simple demonstration of Bernoulli's principle in physics, which is that pressure is reduced at right angles to a stream or current. As it was shown, expressions of astonishment were made by all but seven. One of these said, "That's Bernoulli's Theorem; I took Physics I." Five said, "Opposite to what I expected." Other comments include: "Very amusing." "That's interesting." "I'm anxious to see this—I'm all wrong: it sank." "It seemed to drop in center for some reason." "Oh, I see: suction pulls it down"; or "It's sucked down," by three. "Gee, that's funny. I've got to explain that one!" Another, "That's funny: I didn't believe it!" "Paper bent almost in half—bent down in center. Do that again!" [Investigator repeats demonstration.] "I wondered if some of breath went above the paper." Two also tried it for themselves. One observed, "Well, the pressure seems to come from above."

As indicated in the preceding quotations, several include explanation in their description of what they saw.

When asked, "How do you account for what you saw?" seven stated that there was greater pressure above or that "air beneath is pushed away." The one who mentioned Bernoulli above gave a fairly clear statement of the principle. Another said, "Lessened air resistance underneath: after your breath was gone, it yielded in the middle; you had a full storm under there for a moment and then it subsided and the weight of the paper made it yield. Hm, that's very interesting—makes me think of the old days in Physics." "You upset equilibrium—equal pressure above and beneath—so that for the moment pressure above is greater." The tendency to consider that when a name is given to it, a phenomenon is thereby explained, was illustrated by 25, who used "vacuum" or "suction" or both. One said: "Created a little vacuum, did you?—which would tend to draw paper down; or would there be a vacuum?—must be something draws it down." Another, "Probably same sort of thing that makes a window curtain blow out when there's a wind outside—sort of suction, but I don't understand it very well. Is that right?" One added, "I'm reminded of chimneys—why things fly about in them." The three not included above: "Air pressure bends up [pointing to sides of boxes]." "The fact that volume went to this side and pulled the paper down—probably paper was unevenly balanced." "I don't know if I can figure out why unless—[shakes head]—I give up." Another commented, "It appears to be a trick."

DEMONSTRATION NO. 3: SPOOL AND CARD

This is another example of the Bernoulli effect.

"I have here an ordinary empty spool and a small piece of cardboard. If I hold the card [supported by finger] under the spool and blow through the spool, removing finger when I start to blow, what will happen?"

Twelve predicted the card would fall or drop; 11 that it would be blown away. One of the latter, "I'm puzzled in the light of the last experiment; offhand, I'd say it'll be blown off." Two others added, "If you suck breath in, paper will stay." Another stipulation, "You'll eventually blow it off but not right away." Ten predicted card would "stick to spool." Five of these referred to preceding demonstration; four, "I think that it will stick." One added, "Ordinarily I'd say there'd be a noise." Another, not tallied above, said, "I've seen that one done with water; I don't know whether it will work with air."

Explanations by those who predicted card would fall or be blown off may be represented by the following: "Well, on the basis of experience, when you blow through a hole, you blow things out of it." Four of them said, "Pressure of breath plus pull of gravity." Several, when challenged to account for the event as forecast, showed doubt or bewilderment: "Greater force above than below card, but I'm prepared to believe it will stay." "Air pressure—I was wondering whether heat in your finger will make any difference in air in the chamber. . . . Now blow and make it stick, probably." "Your breath will force the paper away from the spool—I have a feeling it's not going to happen—it's more intricate than that." "It will not be held by anything, since it is bigger than the spool—normally that's what you'd expect." "I assume the blast of air will be strong enough." And confusion, "Area above is less than area of pressure of atmosphere below, so that conceivably the pasteboard might become concave."

Of those who predicted the card would stay or "stick," "suction" and "vacuum" are called in by seven and another used "adhesion" in much the same way: "It should fall away unless the adhesion holds it up, in other words, your blowing has nothing to do with it. Just trying to fool me!" "Probably get sucked up some way —I don't know how—what's that stick in the middle for?" (A pin is used to prevent card slipping off sidewise. Thirteen subjects noticed it and its function was explained to those who asked about it.) One of them in the midst of his explanation, changed his prediction, "If it's held up, it'll be suction—wait a moment—it's exactly opposite—paper was then [previous experiment] on top—it's now beneath—it'll probably drop." An attempt to relate the result to the skin secretion of the finger, "A little bit of grease may hold it there for a time." And one, "I don't account for it."

When the demonstration was made, there were, as before, some who were quite pleased that their prediction was correct and others who gave expressions of amazement. Only nine made clear-cut statements of the observation, "It remained as long as you blew." Statements of delight and mystification include: "Oh, that's wonderful! Do it again! I remember I wondered if, like former experiment, the event would be contrary to expectation, until when you said, 'blow down,' I gave up that idea." "It stayed longer than I expected." "That's what I suspected." "That really surprises me that it didn't fall. Now then, I wonder why it didn't." "Now, why does it do that? That's what I thought from the way you laid it out." "I saw it struggling to get away." (Personification, again.) "There's something mystical about these things: the obvious thing isn't true!" "You drew your breath in [trickery suspected] and created a vacuum in there."

In explanation of what they had just seen, "suction" or "vacuum" was offered by 14 subjects; one of them said, "As the volume of the air spreads out, it tends to suck the card up." Two explanations were reasoned in the right direction: "Escaping air forces itself out [holding hands flat] and the pressure there is less; 15 pounds of atmospheric pressure below it is constant." "As you blow, the air had to escape somewhere, so it went out at the sides; after you stopped, pressure above and below are the same, so it dropped by gravity." Two others adduced, "currents of a rotary type," one with the added analogy, "like a cyclone." Two referred to "area": "Greater area outside than of hole inside—that doesn't answer the question, does it?" "I think it's area and force." One thought that somehow the pressure of the finger persisted, "It has to do with pressure you put on there before, with your finger and then releasing it." Two appealed to magic and personification: "This is completely contrary to what I would expect of well-behaved air; air is sluiced out at sides and air beneath is pushing up, but that means the air is misbehaving!" and "There is a reason—that thing puzzles me! As you blow you exert pressure and the air below pushes back—the same as when you hit the wall, it will hit back." Another tallied above added, "Didn't have anything to do with saliva, did it?" This and the reference to "grease" above seem to be clear examples of the type of children's explanation which Piaget calls *simple phenomenalism,* i.e., an explanation in terms of a concomitant object or event. Also, 11 failed to attempt any explanation. "I don't know," one of these said, "I didn't learn the reason; I learned that it happened—that's all." Two of those who used "vacuum" may also be included in this last group: "I don't understand it; the card is larger and air currents are thrown upward around the spool, creating a vacuum below—somewhat like last experiment." "Just don't know. It can't be a vacuum; there's suction, somehow—but I don't see how."

DEMONSTRATION NO. 4: JAR AND CANDLE

This set-up was also used by Huang [7, p. 97] and by Keen [9, p. 11].

"I have here a gallon glass jar [placing it on table between investigator and subject] and a candle, which I place here [about 4 inches beyond jar, toward the subject]. When I blow here [investigator points at center of jar, bending forward so that his mouth is level with that point], what will happen?"

The prediction given by 11 was (correctly) that the candle would go out, two of them saying, "flutter and go out"; three, that it might either be blown out or not, one adding, "I think it will continue to burn"; twelve, that the "flame will flicker," three qualifying, "If you blow hard enough"; four, that the flame will bend toward the jar; one, "I think it will affect the flame somehow; I don't know how"; four, that nothing would happen, one of them, "I can't see how anything could happen."

In explaining their predictions, of those who predicted the candle would or might go out, seven stated that the air would go around the jar, one phrasing it most clearly, "I know from recent talk about streamlining that air tends to follow the surface of objects; the two currents will then unite beyond jar." Beside these, one said, "Air will fan out; if ends of fan meet, candle will go out." The other five subjects made statements which seem to be clear examples of the type which Piaget calls *perseveration,* that is, the tendency for the answer to a previous question (spool and card) to carry over into later one: "Well, you'll be creating a difference in pressure at both sides and the air above the candle will come down in both directions." "The air will be so disturbed." "Current goes around both sides of jar, again creating an airless space—is that correct? It's like a bicycle drawn by air currents behind a motorcycle." "Air will be divided and either be diverted or come together: since air is misbehaving, I don't know what to expect." "That's probably still Bernoulli's proposition."

Those who predicted that the flame would flicker seem to have the notion that the jar would act as a wedge, dividing and diverting the current of air. Again, one subject, in explaining it, changed his prediction, "If you blow straight there, it will disturb the air around the jar and reach the flame; but I wouldn't be a bit surprised if it didn't even flicker."

The four who predicted the flame would bend toward the jar gave explanations which seem also to illustrate *perseveration*: "Air currents go out from jar causing air to come toward back of jar—a threatened vacuum there." This one seems to imply the "Nature abhors a vacuum" notion. Two of them said, "As above a suction of the currents will draw it in." Another, "If there's any connection between this and the last two experiments, light should go toward you."

Of those who predicted flame would be affected somehow or that nothing would happen: three said, "The air will disperse [wedge, again] and probably not reach the candle." One added, "If you had a wall there, it would flicker." Others, "I think the stream will divide and come around both sides; if it equalizes, it will keep the flame steady; if not, it won't." "I can't think the air from your mouth could affect the light by going around the jar."

When the demonstration was shown and the subjects were asked to describe what they had seen, of those who predicted the flame would be extinguished, several made no comment; one said, "So my second thought was better." Those who made other predictions used various expressions: "Well, it wavered in a big way!" "Surprises me that it goes out with so little force." "Hmm, certainly a good blower! Instead of that glass acting as a buffer, it acted as a conductor." "It didn't go that way; I saw candle go out and flame blow in this direction." "I see that I was wrong." Two asked that the demonstration be repeated: "Uh huh, suppose you blow lightly so I could see the result." "Did some of the breath come over the top?"

Sixteen attempts at explanation after observation were fairly clear, "Air follows around jar and blows out candle." Three had made this answer above in explaining prediction. The most complete answer was, "Air coming from both sides will cool it below its burning point." Another, "I base that on a diagram of streamlining an automobile." Two merely stated, "Air around jar will be disturbed." Eleven attempts were even less adequate, including the "wedge effect" mentioned above: "Air as it hits jar will fan out and some will circulate around there." "Candle is outside distance where two fans of air meet." "Air follows line of least resistance around jar." "Air above candle will come down in both directions." "The breath of the wind was concentrated; after it sprang together from both sides, it is stronger." "Currents moving more rapidly increased the intensity and volume." "You get some current of air over the top as well as around the sides." "Looked to me as if it was blown out, not snuffed or sucked out." Six said, "I don't know," but three of them continued with an attempt to explain: "I don't know—let's see—(pause)—Well, I'd say this then: I guess the curved surface tends to bend and concentrate the volume of air from your mouth on to the candle." "I wouldn't know; I haven't the slightest idea; I thought there would have to be a direct current of air—unless it goes around both sides of the jar—the shape of the current determined by the shape of the vessel." "I don't know how to explain it but it was blown out by your breath; I don't think the jar has anything to do with it." One said, "I don't know what the principle is." Another added, "Hmm, that's tricky."

(To be concluded in October issue.)

PRESENT AND FUTURE SCIENCE COURSES *

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CENTRAL HIGH SCHOOL has an enrollment of over 3,000 pupils; it is the only public senior high school in Trenton, and also serves two of the three adjoining townships. Thus the school presents a cross-section of the city's population. Trenton is an industrial and manufacturing center, as well as the seat of state government for New Jersey.

The school meets rather well the needs of its college preparatory, or academic, pupils. The usual courses in biology, physics, and chemistry are offered, in that order. These courses represent a compromise between the needs of two extremes within the academic group: some will become engineers, doctors, and specialists of various kinds; for them, technical details and mathematical problems are interesting as well as useful. Others may need a science course for college entrance or may not enter college at all, and in any case have little interest in science as an organized body of subject matter, unless they can see pretty clearly its relation to their daily lives, and to the human needs of their nation and the world. Between these two extremes all possible gradations exist; and it is not always possible to tell where any one individual belongs. In general, we try to teach enough technical material to meet the minimum needs of the budding scientists, and along with it enrich and illustrate and show social significance, as much as time will allow. Perhaps this is wrong in order of emphasis, but it does seem that it would be difficult to get a true or clear picture of the social significance of nitrogen fixation, for example, without knowing what nitrogen fixation is. We try to do both phases of the subject together, so that social significance can show the value and result of the technical details, while at the same time technical details can show the basis for the social significance.

The biology course, perhaps because it is farthest removed from college requirements, has shown the greatest tendency to depart from anatomical intricacies and etymological monstrosities, and to emphasize the ideas and principles that can be of greatest use in bettering the lives of the pupils.

In addition to college preparatory chemistry, we have a course for girls only, called Household Chemistry, more practical and less theoretical and mathematical, and designed to meet the needs of home economics students and prospective nurses. There is no comparable course for boys, at present, but we do have courses in aeronautics available.

For the nonacademic two-thirds of the school we offer two courses of one year each, listed as Science I and Science II. These courses differ from the "diluted" biology and physics which they replace chiefly in two respects: (1) they do not follow any one subject's "logical" organization, and are not limited to any one subject; (2) the point of view is that they attempt to serve the needs of the pupils, insofar as science can help. In practice, Science I has leaned heavily on biological subject matter; but it has not been restricted to that field. Since many of the pupils in Science I classes will take no

* Mr. Manzer's article is the third in a series of reports on science plans and programs in individual schools and school systems. Earlier articles dealt with curricula in the Forest Hills High School, New York, and in the Cleveland, Ohio, schools. Comments and contributions from readers are invited, to the end that SCIENCE EDUCATION may assemble a collection of first-hand accounts of what is being done to meet current conditions and what is being planned to meet conditions expected in the near future.

further science courses in high school, it seems most important to give them a chance to develop some background for understanding the operation of their own bodies. Work on health and disease, on food, and on body functions, makes up a large part of the core of the course. Other topics may include insects, heating and ventilation, conservation, electricity in the home, etc. Several different teachers have Science I classes, and transfers are sometimes unavoidable; consequently there must, and presumably there should, be some uniformity to the course. However, there is considerable freedom to vary the activities of the classes in accordance with their (and the teacher's) interests and experiences, and to take advantage of varying situations when they arise.

The second year, Science II, naturally is mostly physical science—but not just physics and chemistry. For example, it includes units on astronomy and on weather and climate. In general the same comments apply to Science II as to Science I. In both cases, we use the textbook that comes nearest to what we want, and supplement it with whatever additional material is available or can be secured, including motion picture films when appropriate. The trend is away from rigidly prescribed subject matter, and toward greater freedom to adjust to varying interests and needs.

For the future, we are planning a science course to fit the needs of senior boys who will enter the industries of Trenton as employees shortly after, if not before, graduation from high school. At present some students in our commercial curriculum spend a part of their time, toward the end of their high school course, in actual office work in the city. Thus, they can make the transition from school to work less abruptly, under supervision, and with greater chance for success. It is hoped that it may be possible to make a similar work privilege available to boys of the industrial arts curricula, during the second semester of their senior year. In preparation for seeking the necessary approvals, we are now engaged in planning a one-year science course which will fit in with courses in English and in social studies, and will help to give these boys the information, understandings, and attitudes that they will need for success and happiness in their life and work. Surely there is much in the field of science that we can draw on to help them in the daily work, as well as in the aspects of living. Topics under consideration at present include Health and Safety, Measurement, Energy, Machines, Matter, Oxidation, Food, Heat, Metals and Some Other Important Chemicals, Electricity, and Family Life. Each of these topics will be developed with the needs of this particular group of boys constantly in mind. And when the boys are on a real job, part-time, it may be expected that they will find problems that their science course should attempt to solve. Subject matter of that sort should considerably enliven the course —and the teacher, too.

At any rate it is fun to make the plans. We never do as well as we would like, but we never give up hoping, and planning, and trying, to do better.

TOWARD A MORE ADEQUATE SCIENCE EDUCATION

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SCIENCE is a complex of social institutions. This complex includes not only specialized educational institutions, but academic, professional, and industrial associations. It includes state, national, and international organizations, institutes, and foundations. It includes, moreover, a vast multilingual literature, codes of professional ethics, and established conventions. The profusion, variety, and catholicity of this social complex becomes apparent in a mere listing of some of the outstanding scientific institutions:

- Academia dei Lincei, founded in 1603
- Academia del Cimento, founded in 1657
- The Royal Society of Britain, founded in 1662
- Academie des Sciences, founded in 1666
- Imperatorskaya Akademiya Nauk, established in 1718
- Preussiche Akademie der Wissenschaften, founded in 1700
- The Royal Swedish Academy, founded in 1741
- Academie Imperiale des Sciences de Saint Petersbourg, founded in 1779
- The American Academy of Arts and Sciences, founded in 1780
- The American Association for the Advancement of Science, founded in 1848

Among the more recently established institutions are:

- The American Chemical Society
- The Union of American Biological Societies
- The Institute of Biology and Experimental Medicine of Buenos Aires
- The Government Testing Laboratory of South Africa
- The Karolinska Institute in Sweden
- The Mendeleev Institute of Chemical Technology in Russia
- The Leningrad Optical Institute
- The Rowett Agricultural Research Institute in Great Britain

Our own times have witnessed the unprecedented development of industrial research laboratories, such as those of the General Electric Company, Eastman Kodak Company, Bell Telephone Company, Merck & Company, and others. These are rapidly overtaking our university laboratories at the forefront of research and are drawing unto themselves men and women of great ability and rare talents.

The social complex constituting "science" also includes museums and libraries, botanic gardens and reservations, agricultural stations and proving grounds, meteorological observations outposts and bureaus, health stations and quarantine agencies. It includes Councils, Authorities, and Surveys, such as the India Council of Scientific and Industrial Research, our own National Advisory Council, Civil Aeronautics Authority, Geological Survey, and Bureau of Mines.

These institutions are integrated by means of a vast and rapidly growing literature. Since the establishment in 1665 of the *Journal des Savants* and the *Philosophical Transactions of the Royal Society*, publications carrying reports of investigations, experiments, and discoveries have multiplied as areas of organized knowledge have proliferated into literally hundreds of specializations from acoustics, antibiotics, and electronics to psychoanalysis, zoogeography and zymology.

The foundation for this vast complex of social organization is the conviction, based upon experience, that nature is consistent and therefore predictable. An event is observed to take place under certain conditions; it follows that, given these conditions, the event will take place again. This conviction has united men of different nationalities, languages, races, and indeed of different generations. It has brought forth a world culture. It has revolutionized our conception of the universe. It has yielded for human beings such powers as were probably beyond the wildest imagination of any man of any pre-scientific age. (It may be significant that the early scientific academies were founded by potentates who may have seen, or whose advisors may have seen, in the new arts great sources of wealth and of power.)

The powers thus acquired by man have reorganized and continue to reorganize the economic, political, and social structure of our society. They are accelerating and disintegrating our living even as they are prolonging and enriching our lives. They are producing social integrations and disintegrations as are beyond the ability of any individual's nervous system to comprehend, much less to control. They have made men dependent upon machines which they frequently do not understand. Gas tanks are filled by men who never heard of aliphatic compounds to power cars driven by men who never heard of Boyle's law or of entropy. The person is rare, indeed, who knows what goes on at a central station as he dials his telephone.

Consequently, there has developed a new object of awe and of worship. It, too, is called *Science*. To an overwhelming majority of people, this term has come to mean the *products* of research—machines, apparatuses, instruments, power plants, gadgets, and chemicals. A smaller number of people identify science with research agencies and agencies for the dissemination and exchange of research findings. To many of these people the men who work in laboratories constitute the new priesthood. To a lamentably small number of people does science connote not mechanization and gadgetry, not a new priesthood of the test tube and slide rule, but *a method of arriving at useful information,* useful, that is, for whatever purposes angelic, diabolic, or insipid which men may be brought up, or impelled, or persuaded to pursue.

The fundamental *elements of scientific information* are verifiable sense impressions frequently integrated by mathematical relationships. A further integration is secured through the formulation of hypotheses which, tested by further observation and controlled experimentation, may be raised to the level of theory and eventually even of fact. (The term *fact* as used here may be defined as that upon which *all* competent observers agree.)

The fundamental *elements of scientific method* are meticulous observation, careful recording, skill in establishing qualitative and quantitative relationships, creative imagination in formulating hypotheses, and skill in reporting research findings.

The fundamental *elements of scientific thinking* are the tendency to be critical of the meticulousness of an observation; the readiness to distinguish between an hypothesis, a theory, and a fact; a thirst for evidence, and the ability to judge the pertinence and adequacy of evidence.

In the scientific mind, these abilities are coupled with a set of mental attitudes, many of them social in nature. These include a willingness to publish research findings without direct monetary remuneration, the willingness to grant credit through citations of work done by others, the willingness to recognize rules of priority, the readiness to encourage the repetition by others of work reported on.

Those who conceive of science as *method* do not identify technological invention with moral progress. Nor do they, upon entering the political arena, the social forum, or the church, revert to the primitive condition of thinking with their emotions. They are likely to assess better the limitations of science. With Karl Pearson, they realize that "science may be described as a classified index to the successive pages of sense impressions which enables us readily to find what we want but in no wise accounts for the peculiar contents of that book of life." We might add that these pages of sense impressions, although checked and double checked against experience, constitute, after all, a monumental product of the human imagination.

What Should Constitute Science Education?

The term *education,* as it is used here, may be defined as socially directed and controlled acculturation. A society establishes educational institutions in order to provide for its own perpetuation and evolution. The extent to which our own society depends upon technology and technological products necessitates a steady supply of technicians. The extent to which technological products enter into the daily lives of individuals and of communities calls for bringing up our youth to handle these products efficiently and to exercise over them such social controls as may be dictated by ethical considerations.

A society which transmits from one generation to the next its technology without at the same time inculcating ethical purpose is merely accelerating its own disintegration. For this reason, a society cannot afford to employ science teachers in its secondary schools who are mere technicians or self-styled oracles of a new truth.

Nor can a society afford to employ social studies teachers who, while they teach an idealized history of science and while they emphasize the influence of science on society, have nevertheless such a narrow conception of what constitutes science that they fail to apply the scientific method of thinking to social phenomena.

The young men and women leaving our secondary schools today frequently come out with an indoctrinated attitude toward science but without scientific attitudes. Clever commercial advertisers have learned to exploit this widespread product of miseducation, to employ popular shibboleths of what passes of science education, and to make an emotional tie-up with science, "bestowing its blessing upon thousands."

To make its proper contribution to the lives of people in our society and to the evolution of our society itself, science education must provide not only an abundance of direct experiences with natural phenomena leading to psychological assimilation of general principles; it must provide as well experiences which will establish the scientific method of thinking in all aspects of living to which it is applicable. It must provide experiences which will build up the conception that no investigator is self-sufficient, but, like Sir Isaac Newton, every investigator "stands upon the shoulders of giants" of several generations widely distributed over the earth and linked to each other by a vast, painstakingly written, and rapidly growing literature. It must provide, moreover, experiences leading to an appreciation of certain principles of professional ethics which govern the great scientific fraternity of our day. And, not the least in importance, it must provide experiences leading to an appreciation of the fact that men and women engaged in scientific work are human beings subject to all the usual religious, social, and economic influences which condition the attitudes, aspirations, and behavior of human beings.

EDUCATIONAL TRENDS

ON THE TEACHING OF THE BASIC SCIENCES

A Committee Report *

On May 1, 1943, U. S. Commissioner of Education J. W. Studebaker asked for the formation of a committee to "canvass carefully the question of whether the basic sciences should not be included along with vocational education in a federally subsidized program. Such a subsidization would include, of course, the appropriate training of teachers for such courses." At that time a committee was already at work to study the needs of industry for the training of engineering aides in technical institutes and other institutions of comparable grade in the vocational-technical training program (J. C. Wright's committee, with Professor L. A. Emerson of Cornell University as chairman of the working committee). It was decided that the present committee on basic sciences should be small and should represent the Commission on Teacher Education (Karl W. Bigelow), research in science teaching (R. J. Havighurst), the division of higher education of the United States Office of Education (F. J. Kelly) and the sciences (K. Lark-Horovitz, chairman of the committee).

Members of the committee have discussed the problem on various occasions with many different groups and individuals. From all these discussions, it became evident that while the public in general regrets the extension of federal aid, particularly if this means federal control, it is recognized that federal aid of some kind will be necessary to strengthen the teaching of the basic sciences. A plan will have to be worked out which will guarantee that such aid will not be accompanied by federal control.

The committee met at the U. S. Office of Education on May 20, 1944, and, in its discussions, summarized the situation as follows. In reviewing the results of recent studies, one finds:

(1) A conspicuous lack of training in the physical sciences in the secondary schools, so that at any one time only about 7 per cent of the total high school population is enrolled in physics or chemistry, whereas a large number is enrolled in the biological sciences (biology, zoology, botany, hygiene, and so forth).

(2) This is owing to the fact that more than half of our schools have six or less teachers and, under the present licensing and certification system, most of these schools cannot afford to hire a teacher for the physical sciences.

(3) Some of the best science teaching in smaller high schools is carried on by the teachers of agriculture in states in which the time of such teachers is prorated and they do not spend all their time in vocational agriculture. In the teacher training programs set up to prepare these vocational teachers, a considerable amount of science is required.

(4) The teachers now teaching science in the high schools are, in many states, poorly prepared in their respective subjects, being on the whole measurably less well prepared than trainees in the same field for industry.

(5) Because only a small proportion of high school students takes science at the present time, those who teach these sciences must combine science with some other subjects. Many of the teachers have to teach three, four or even more subjects which may be almost entirely unrelated. The result is that such science teaching has to be assigned to individuals whose main interest is in some other subject, for whom science was only a minor subject in college.

(6) This situation could be remedied by certification of science teachers in comprehensive areas, such as a combination of the physical sciences with the biological sciences or of the physical sciences with mathematics and geography.

(7) It is necessary to realize that teachers trained in such comprehensive science areas are also potential candidates for industrial positions. Since the starting salary and the life expectancy of earnings are far higher in industry than in the schools, we must be able to compete with industry in order to attract teachers who are well trained and have aptitude in the physical sciences

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and mathematics. This is all the more true because men are more likely than women to specialize in science and mathematics, and men—with their family responsibilities—can less afford to continue teaching at low salaries.

In the rural schools all over the country and in almost all school systems in the southern states, the financial situation of the teachers is such that it is difficult to provide the necessary number of teachers for the science jobs. In some parts of the country it might be possible to correct this situation locally, particularly in industrial sections where the community may insist on a better background for future employees. In many parts of the South, however, an increase in local taxes seems to be impossible and therefore some other source of funds will have to be found to raise the standard of teachers' training and to hold well-trained teachers in teaching positions.

It is evident that the only way to remedy this situation—to attract and hold able, well-prepared science and mathematics teachers in the high schools, and thus to insure an adequate basic training for those who are to receive vocational and technical education—is to find some way of increasing the salaries of such teachers. This would (i) reduce the loss of such teachers to industry; (ii) encourage more able college students to prepare for such teaching; and (iii) facilitate the assignment of basic science and mathematics courses to teachers of vocational and technical subjects, who frequently have received superior preparation in these fields but who tend not to teach them because present provisions for augmentation of their salaries by federal aid do not apply except insofar as they offer strictly vocational and technical instruction.

The existing provisions for federal aid to provide better salaries for teachers of vocational and technical subjects provide a precedent for similar action with respect to science and mathematics teachers and show how effective and satisfactory such action could be expected to be. The nation is already committed to a program of federally aided vocational-technical education in the schools. In 1942, the appropriations totaled about $286,401,000, of which about $230,690,000 represented emergency appropriations. This work has demonstrated its value and also the fact that federal aid does not necessarily involve an undesirable degree of federal control.

No single policy can be said to characterize all of these programs. Some of them are largely dominated by federal administrative authority; others are almost free of federal influence. It is probably fair to assume that if the federal government or any other appropriating body feels it necessary to appropiate money for any purpose, that body will assume enough control over the expenditure to assure itself that the purposes for which the appropriations were made are accomplished. Any other assumption would appear to be unrealistic.

Provision for the training of vocational teachers is definitely made by the Smith-Hughes and the George-Deen Acts—the two acts in accordance with which the federal government and the states cooperate in the promotion of certain types of vocational education.

A principal feature of the cooperative arrangement established between the federal government and the states is the provision for state plans. A state plan is prepared by the state board for vocational education, and it is then submitted to the U. S. Office of Education, which approves the plan if it is found to be in conformity with the provisions and purposes of the federal legislation. In the plan will be found such items as the kinds of vocational education for which the appropriations are to be used, the kinds of schools and equipment, qualifications of teachers and plans for the training of teachers. *It will be apparent that a state has much leeway in preparing its plan.* The only requirement is that the plan shall be in conformity with the law. The arrangement for the administration of vocational education is distinctly a cooperative one which operates within the framework of the federal legislation.

This provision is typical of what may be expected of any law that is intended to provide for teacher training through federal funds. That it does not appear to contemplate very seriously federal control becomes also clear if one studies the training programs in teacher-training institutions in the various states. This program varies widely from institution to institution. As long as the standards of teaching are met, there is no further interference with the local plan of the training institutions or with the state board in its program of teachers' training.

It has been recognized that technical training, not for a narrow specific area, but rather for a family of occupations and a comprehensive area of skills, is essential if the future employee is to be adaptable to varying employment conditions and to a variety of demands in one and the same industry. Moreover, training for the war effort, as in the ESMWT program and in the vocational war production training program, has brought out clearly that there are new areas of vocational and technical occupations for which training seems to be necessary and advisable. Engineering aides, technicians and laboratory assistants in the various branches of chemical, electrical and mechanical industry could be prepared in new courses enlarging the present program, if this were made a permanent part of the secondary school curriculum.

It is accordingly proposed by this committee that existing legislation relating to vocational and technical education be amended and future legislation be formulated to include provision, in addition to that now provided for such fields as vocational agriculture, home economics, trades and industries, and distributive occupations, for *"the sciences basic thereto and (or including) mathematics."*

Such amendment, specifically as relating to the sections of the law having to do with the preparation and employment of teachers, would have the following effects:

(1) As in the case of vocational agricultural and other vocational teachers, the standards which are set up by the state department of education in cooperation with the U. S. Office of Education will have to be met. This guarantees that certain minimum requirements would have to be fulfilled if federal aid is to be obtained for the teaching of the sciences and mathematics as basic to agriculture, trades and industries, distributive occupations, and the proposed vocational-technical training.

(2) Since the effectiveness of engineering, technical and vocational education and training is largely dependent on the soundness of preparatory education in mathematics, physics and chemistry, programs of teacher training under existing and future acts supplying federal support for teacher training should then include provision for teacher training in these fields.

The proposed amendment might well be part of a further modification of existing legislation that would also provide for:

(1) Expansion of the present vocational and technical education program (now limited to work "of less than college grade") to encompass activities "of scholastic standard commonly associated with work done in high school and in the first two years beyond high school, but excluding that done as part of a regular four-year curriculum";

(2) Authorization to the states to make use of and allocate support to the facilities of tax-exempt, though not publicly supported, universities, junior colleges, technical institutes, and the like, as well as to those publicly controlled;

(3) Requirement that states—if they desire to participate—designate or create state boards to exercise control over the program within their boundaries, such boards to consist of not less than seven members so selected as to be representative of the various fields of interest for which the vocational and technical programs prepare.

The justification for the foregoing proposals is that the teaching of science is so intimately related to the whole program of vocational and technical education that it seems desirable to integrate it with that program. Use of federal funds is justified because the programs which already involve federal funds will be strengthened by better science teaching and also because the developments now foreseen in the field of technical education will be seriously handicapped unless better science teaching is assured. It, therefore, seems desirable to look forward to a single program of vocational and technical education involving the present programs carried under the Smith-Hughes and George-Deen Acts as well as the more advanced programs now developing in technical education intimately associated with them. This single program, which may be called " vocational and technical education," cannot well succeed unless the supporting sciences are strengthened in the high schools.

It is evident that an expansion of such programs will be called for as the war approaches its end and the shift to peacetime conditions becomes necessary. This program, geared to the increasingly technical character of occupations:

(1) Will meet the special problems of vocation readjustment for returned servicemen and war-industry employees;

(2) Will satisfy the need for opportunities for such training by persons who have completed high school, and aid the development of post-high school technical institutes and the like;

(3) Will make it possible for the small as well as the large high schools to provide adequate science and mathematics instruction and to enable their graduates successfully to pursue these vocational-technical courses as well as regular college courses in such fields as engineering;

(4) Would increase availability of vocational and technical education to young people who grow up in communities too small to provide such training locally; and

(5) Would guarantee that the interests most vitally involved would have a voice in the working out of the programs in the several states.

In summary, it may be said that the two sets of modifications proposed would have the following advantageous effects:

(1) Provision of adequately trained teachers in the sciences; better preparation of science teachers will come only with better salaries; better salaries can be assured only by including the teachers of sciences which are basic to technical education in the same program of federal subsidies as the teachers of technical subjects.

(2) Improvement of the basic preparation—in science and mathematics—of persons for whom present and prospective provision of vocational and technical education is designed. This is essential to the effective functioning of any vocational and technical program.

(3) Incidental improvement of the instruction in science received by high school students not planning to enter vocational and technical programs. Many such students would take the same courses as those for whose benefit the proposals in this report are specifically designed. Since science and mathematics are important elements in the preparation of every young citizen for participation in contemporary life—every aspect of which is increasingly affected by scientific developments—this incidental consequence must be considered an additional advantage. (If, however, it should be deemed improper or undesirable even incidentally to permit federal funds to be used to improve general education, the difficulty could be dealt with by providing that the federal contribution to the salaries of science and mathematics teachers should be less than the half now given in the case of teachers of strictly vocational and technical courses.)

(4) Establishment of a unified, properly supported program of vocational and technical education, including the mathematics and sciences that are essential elements therein, together with such post-high school work as is called for by the realities of the situation with which the country is faced, and making efficient use of the facilities of tax-exempt privately controlled, as well as of publicly controlled, educational institutions.

(5) Encouragement of the development of a technical-institute type of training at the post-high school level called for by the needs of many occupations, geared to the programs of the high school below and properly differentiated for the advanced professional programs offered by engineering schools and comparable collegiate units.

(6) Guarantee—through the proposed state boards—of local control, representing all leading interests in the problems in question.

A DETERMINATION OF THE PRINCIPLES OF THE BIOLOGICAL SCIENCES OF IMPORTANCE FOR GENERAL EDUCATION. II

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In a study directed toward the determination of the principles of the biological sciences which are of importance for general education, the first, or inductive, phase resulted in the development of a tentative list of important biological principles.[1] The purpose of the second, or deductive, phase of the study was to determine those principles in this "major" list which are of importance as objectives of instruction in science in a program of general education.

Before the solution of this major problem could be undertaken it was necessary to secure and survey sources from which it might be possible to derive evidence as to (1) the phenomena of everyday living which require a knowledge of a principle or principles of science for their interpretation, and (2) the problems most frequently encountered in the everyday experiences of the average individual, which require an understanding of a principle or principles of science for their effective solution.

Some of the possible sources of evidence of such phenomena and problems were:

(1) Diaries of the daily activities of individuals from different occupations and professions;
(2) Lists of the daily activities of individuals, secured by the questionnaire technique, from a representative sampling of the rural and urban population;
(3) Lists of the "needs" of adolescents as secured from reports of research studies:
(4) Lists of the problems of adolescents as secured from reports of research studies;
(5) Lists of the scientific interests of adolescents and adults from reports of research studies;
(6) Analyses of the materials dealing with science in radio programs;
(7) Analyses of motion pictures for scientific materials;
(8) Analyses to determine the scientific materials published in magazine and newspapers for reading by the general public.

From a consideration of the possibilities and limitations of these different sources, and extensive readings in the literature related to each, it was decided that for purposes of this study the sources most likely to prove suitable were the lists of "needs" of adolescents, and the scientific materials published in magazines and newspapers.

A preliminary investigation to determine a list of the "needs" of adolescents, as they appear in published surveys and research studies, revealed that (1) the "needs" in the various lists could not be arranged defensibly into suitable categories, and (2) the lists of "needs" could not be formulated into a defensible composite list. Thus for these reasons, lists of the "needs" of adolescents were considered to be unsuitable to serve as a source.

A survey of research studies [2] relating to biological materials in newspapers and magazines and a comparison of the results of the studies and conclusions of the investigators revealed that:

(1) Biology is the most common branch of science occurring in the representative newspapers and magazines selected for analysis in the studies, and if frequency of occurrence is an evidence of relative importance, it might thus be regarded as the most important of all secondary school sciences from the standpoint of general educational values.
(2) There is a marked agreement in the findings as to those topics which occur most frequently in the sources used. These topics, on the basis of their frequency of occurrence in the lists of the six most important topics in each study are:

Human Biology, Health and Disease..	(6)
Animal Biology	(6)
Foods and Nutrition..................	(6)
Plant Biology	(3)

(3) The scientific topics discussed in newspapers and magazines constitute a valid guide to the phases of science which are of consistently great interest because of their close relationship to everyday experiences.

NEWSPAPERS AND MAGAZINES AS A SOURCE OF BIOLOGICAL INFORMATION

Thus it was assumed, on the basis of these findings, that the public press and the non-specialized magazines constitute a comprehensive and reliable source of science materials, and that these materials explain and interpret the phenomena and problems of the everyday experiences of the average individual in terms of which the biological principles of the "major" and "minor" lists might be evaluated.

On the basis of this assumption, the major problem was divided into three sub-problems, the first of which was investigated as follows:

Sub-Problem I: To determine which principles of the "major" list and of the "minor" list, previously determined, must be comprehended in order to permit an understanding of scientific materials appearing in selected magazines and newspapers.

Techniques Employed

A series of consultations was held, with the committee members who cooperated in the inductive phase of the study (three persons engaged in the teaching of science and the training of teachers), to select the magazines and newspapers to be used as sources of science materials. As a result of these consultations *Hygeia* was selected as the magazine most likely to yield reliable materials related to the topics Human Biology, Health, Diseases, Foods and Nutrition. *Nature Magazine* was designated as being most likely to yield materials related to Animal and Plant Biology. The magazines selected by the investigator as being representative of the many non-specialized magazines available were *Life* and *Readers Digest.*

On the recommendation of the committee it was assumed that two years' consecutive issues of each of these four magazines would constitute an adequate sampling of the materials appearing in them. Hence every article in each issue of each of the magazines for the period from January 1, 1942, to December 31, 1943, was used in the investigation.

The three newspapers used as sources of scientific materials were chosen arbitrarily by the investigator from those which published Sunday supplements and which would be likely to contain scientific materials representative of the various areas of the country. For the East coast area *The New York Times* was the newspaper selected; for the Middle-West, *The Chicago Herald and Examiner* and *The Chicago Herald American;* for the West coast *The San Francisco Chronicle.*

In order to ensure that the sampling of scientific materials from the supplements of these newspapers would not be affected in a significant manner by the economic and social conditions prevailing over a limited period of a year or two, it was decided to use a random sampling of the issues of these newspapers published between January 1, 1929, and December 31, 1943, inclusive. It was assumed that such a random sampling would provide scientific materials which were representative of the interests of the "boom" years, centering in the year 1929, of the pre-depression year, of the depression years, of the recovery years, and of the war years. In all, the Sunday supplements of 24 issues were analyzed.

Before the analysis was undertaken criteria were set up by the investigator assisted by the committee who cooperated in the inductive phase of the study, in terms of which the biological materials could be selected and evaluated. These criteria were:

Knowledge of a biological principle is assumed to be necessary for an understanding of the content of an article:

(1) If a literal and/or direct statement of the principle is made in the article.
(2) If, though it does not state the principle directly, any statement from the article can be restated in such a way as to do so; or if the statement can be combined justifiably with an accompanying statement from the source, into an acceptable statement of the principle.
(3) If, in the opinion of the investigator, a knowledge of the principle is necessary for a clear understanding and appreciation of the true biological significance of the content of the article. This criterion is satisfied:
   a. If the content of an article relates unquestionably to a biological principle by furnishing a clear illustration of it;
   b. If it includes a term, or terms, which are unquestionably related to a principle, and which require an understanding of the principle for an understanding of the term;
   c. If it discusses or describes processes, interactions, or relationships which are unquestionably related to a principle.

The analysis of the materials in the sources was made as follows: Every article in each issue was given an initial reading by the investigator. A mark was made in the margin opposite every statement which was considered to satisfy one or more of the three criteria. On the second reading of the article, every statement marked during the first reading was considered in relation to its context, as a means of deciding more definitely whether it satisfied the criteria. If, in the opinion of the investigator, it did satisfy any one of the criteria, a check (√) was made on the "major" list opposite the principle, or principles, to which the statement was directly related. Any statement which was considered to be related to a biological generalization, but which was too limited in scope to be related justifiably to a "major" principle, was assigned to the "minor" principle to which it was judged to be related.[1]

Each principle in the "major" list and in the "minor" list which had received one or more checks in the analysis of an article, was then arbitrarily assigned a frequency of 1 on an identical "major" or "minor" list. The checks appearing on the tabulation sheets were then erased in preparation for the tabulation of the data from the analysis of the next article in the source. Thus each checked principle was arbitrarily assigned a frequency of 1 for each article in which it was designated once or oftener. This was done on the assumption that the knowledge of the principle necessary for an interpretation of any one statement in the article would apply equally to all other statements in the same article which were related to it.

In the course of the analysis any statement, which was considered to be a statement of a biological generalization but for which a principle did not appear in either the "major" or the "minor" list, was tentatively added, worded as it appeared in the source, to the "major" list under the topic heading to which it seemed most logically to belong. Each statement so added was submitted later both to the committee for evaluation in terms of the criteria set up for the determination of a principle, and to the subject-matter specialists for evaluation as to the technical accuracy of the statement. Upon approval by all members of both groups, it was accepted as a principle.

The analysis, tabulation, and recording of the frequencies for each article were completed before the analysis of the next article was undertaken. On completion of the analysis of all the articles, the total of the frequencies of assignment of statements for each of the principles in the "major" and "minor" lists was determined.

Findings

The 300 major principles and the 236 minor principles had a total of 2,573 statements (articles) assigned to them from the magazine and newspaper articles used as sources of scientific materials. These statements were distributed as follows: 1,366 statements from *Hygeia* and *Nature Magazine* were assigned to 181 major principles and 115 minor principles; 887 statements from *Life* and *Readers Digest* were assigned to 147 major principles and 84 minor principles; and 320 statements from the Sunday supplements of the 24 issues of the three newspapers were assigned to 97 major principles and 27 minor principles.

There were 78 major principles which had no statements assigned to them from any of the sources used.

The twenty major principles, receiving the highest ranks on the basis of the total frequency of assignment of statements to each major principle and to the minor principles related to it, follow in the decreasing order of their importance:

(1) Infection by microorganisms is possible only under the following conditions: (1) The infecting organisms must enter the host in sufficient numbers; (2) It must enter by an appropriate avenue; (3) It must be virulent; (4) The host must be receptive.

(2) All communicable diseases are caused by microorganisms.

(3) The antitoxins produced by the body of an organism are specific.

(4) The food requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement for the slight wearing away of the living tissues involved in any activity; minerals, the necessary constituents of cell structure, of cell products, and of the bathing fluid of cells.

(5) Most cases of fermentation, souring, and putrefaction are brought about by living organisms.

(6) Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals.

(7) A parasitic organism harms its host in various ways and to various degrees, by actively attacking the tissues, by shedding poisons (toxins) which are distributed throughout the body of the host, by competing with the host for food, or even by making reproduction of the host impossible.

(8) Food, oxygen, certain optimal conditions of temperature, moisture, and light, are essential to the life of most living things.

(9) Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system

(10) The biological functions of color are to conceal, to disguise, or to advertise.

(11) Protective adaptations aid survival.

(12.5) The cell is the unit of structure and func- in all organisms.

(12.5) The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the growth and repair or upbuilding or protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

(14) Enzymes, vitamins, and hormones are chemical regulators (stimulators and suppressors) of the reactions that occur in living organisms.

(15) The surface of the earth and the atmosphere surrounding the earth are undergoing constant changes; therefore in order to survive, organisms must migrate, hibernate, aestivate, build artificial shelters or otherwise become adapted to these changes.

(16) All gradations of association occur in intimate associations between organisms, from those which are mutually beneficial to the individuals concerned (symbiosis) to those in which one member secures all the advantage at the expense of the other (parasitism).

(17) All plants and animals are engaged in a constant struggle for energy.

(18) Cells are organized into tissues, tissues into organs, and organs into systems, the better to carry on the functions of complex organisms.

(19) Digestion accomplishes two things: it makes food soluble in water, thus enabling the nutrients to pass through membranes and thereby reach and enter the cells; it reduces complex nutrients (fats, proteins, and carbohydrates) to simple building materials which in turn can be rebuilt into whatever living material or structural feature is necessary at the place of use.

(20) A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment.

CHECK ON THE RELIABILITY OF THE ANALYSIS

On completion of the analyses of the magazine and newspaper materials, it was evident that there were three possible sources of variability inherent in the method of analysis employed. This variability could result from the subjective factor of human judgment in:

(1) The selection of statements from the articles;
(2) The evaluation of each statement in terms of the criteria;
(3) The assigning of the statement to the principle or principles in the "major" or the "minor" list.

In order to test the reliability of the investigator's judgment on these three phases of the analysis, the materials in one issue selected at random from each of the different sources used were analyzed again. Exactly the same criteria and techniques were used in the check analysis as had been used in the original analysis.

The quotient (ratio) obtained by dividing the number of statements common to the two different analyses by the total number of different statements assigned to principles in the original analysis and in the check analysis was assumed to be an indication of the reliability of the investigator's judgment in assigning statements from the sources to the "major" and "minor" principles in the lists.

Findings

The number of statements common to the two different analyses was 52. The total number of different statements assigned to principles in the two analyses was 57. The ratio was .912.

If it is assumed that the materials selected for reanalysis represent an adequate sampling of the basic sources used, then the ratio, .912, indicates that the original analysis of all the sources was reliable, and that most of the statements in the sources were secured and defensibly assigned to the principle or principles to which they are related.

JUDGMENTS OF THE IMPORTANCE OF PRINCIPLES

Sub-Problem II: To determine from the judgments of selected specialists and laymen, which principles in the "major" and the "minor" lists need to be understood for purposes of general education.

Techniques Employed

The "major" and "minor" lists of principles were organized into rating sheets which were presented to each of three teachers and two laymen who served as raters. Each of the raters was instructed personally by the investigator; the directions for rating the principles were given verbally, and the system for marking the principles demonstrated.

Prior to the interview, each principle in the "major" list to which the subject-matter specialists, who cooperated in the inductive phase, had added exceptions, had been marked with an asterisk, and the exceptions noted by the specialists had been written in pencil in the margin of the list opposite the principle.

Each rater was instructed to consider each principle in relation to the exceptions noted, and if in his opinion the exceptions were important enough to invalidate the principle for instructional purposes, to draw a circle around the principle. Any statement which was so marked by all of the raters was dropped from the list.

Each evaluator was then instructed to indicate his judgment as to the suitability of each principle in the lists for use as an objective of science instruction in a program of general education, by marking each principle with a numeral in accordance with the following code:

(1) Not at all suited
(2) Poorly suited
(3) Neither well nor poorly suited
(4) well suited
(5) Ideally suited.

Each evaluator was also asked to add to the "major" list other principles which he considered either "well suited" or "ideally suited" for general education purposes, and to evaluate each principle thus added in accordance with the code. Each principle in the "minor" list was evaluated in the same manner in accordance with the code.

The data secured from these evaluations were tabulated and the mean of the ratings for each " major " and " minor " principle computed.

Findings

A total of 102 " major " principles and 26 " minor " principles received a mean value of 5.00, that is, they were judged by all the evaluators to be " ideally suited " to serve as objectives of instruction. Of the 300 major principles, 296 secured a mean value of 2.5 or more, and thus were considered to be suitable.

DETERMINING THE IMPORTANT PRINCIPLES

Sub-Problem III: To determine the principles of the biological sciences which are of importance for purposes of general education.

Techniques Employed

In each of the preceding steps of this investigation the data which had been secured relative to each " major " and " minor " principle had been recorded on the card on which the original statement of the principle had been recorded. The cards bearing the statements of the " major " principles had been arranged in a file under apppropriate topic-headings, those bearing the statements of the " minor " principles were arranged in another file under identical topic-headings.

As the first step, each minor principle was considered in relation to each of the major principles under the same topic-heading in the file, to determine the " major " principle to which it was most nearly related. The card, bearing the statement of the " minor " principle and all the data relevant to it, was then clipped to the card bearing the statement of the " major " principle to which, in the opinion of the investigator, it was most nearly related. A similar procedure was followed with each " minor " principle in the file.

Any " minor " principle which could not be defensibly related to a " major " principle was relegated to a section labelled " Miscellaneous Minor Principles."

When all the " minor " principles had been evaluated according to this technique, and each had been assigned, either to a " major " principle or to the miscellaneous section, the complete file was submitted to one of the members of the committee co-operating throughout this study. This member critically examined each principle in the file to insure that the assignment of each minor principle to its related major principle was defensible. No assignment was considered defensible unless both the investigator and the cooperating committee member considered it so.

The next step was the tabulation of the data which had been secured relative to each of the major principles and the minor principles assigned to it.

Each " major " principle was arbitrarily assigned the total of all the statements from the magazine and newspaper materials which had been assigned to it in Sub-Problem I and to all the principles related to it. This was done on the assumption that each minor principle is subsidiary to the major principle to which it is assigned, and that an understanding of the minor principle is considered contributory to an understanding of the major principle to which it is related. Thus, if the comprehension of a minor principle is considered essential for an understanding of a statement appearing in an article, it can be defensibly assumed that a comprehension of the major principle is necessary for an understanding of the full biological significance of the materials in the article in which the statement appears. On completion of the tabulation of the data secured in the analysis of the articles from the magazines and newspapers the 300 major principles were ranked in descending order, on the basis of the total frequency of assignment of statements to each " major " principle and to the minor principles related to it.

Each major principle was also arbitrarily assigned the highest mean value (given by the evaluators who rated the principles as to their suitability for purposes of general education) of any minor principle under it, provided that the major principle did not already possess a higher mean value than any of its subsidiary principles. This was done on the assumption that if the composite outline of principles is defensible, no minor principle should possess a higher mean value than that of the major principle under which it is classified and to which it is subsidiary. On completion of the tabulation of the data secured in the evaluation of the principles as to suitability for purposes of general education, the 300 major principles were ranked in descending order on the basis of the mean of the values which each had received from the evaluators, or which had been arbitrarily assigned to it.

In order to secure a comparison of the relative importance of the principles on the basis of the ranks received by each principle in the three investigations, the Pearson product-moment coefficient of correlation and the probable error of the coefficient were computed for each pair of the three different measures secured. These measures were:

(1) The total frequency of appearance of each major principle in the textbooks and lists of research studies.

(2) The total frequency of assignment of statements from the magazine and newspaper articles to each major principle and its related minor principles.

(3) The totals of the values assigned to each major principle by the evaluators.

Findings

The coefficient of correlation for measures 1 and 2 was $.19 \pm .04$; for 1 and 3 it was $.24 \pm .04$, and for 2 and 3 it was $.23 \pm .04$.

ONE HUNDRED MAJOR PRINCIPLES

The 100 major principles, which were found to rank highest in importance for purposes of general education, on the basis of the aggregate of the ranks which each had received in the three evaluations, follow in the order of their decreasing value:

(1) The food requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement for the slight wearing away of the living tissue involved in any activity; minerals, the necessary constituents of cell structures, of cell products, and of the bathing fluid of cells.

(2) The cell is the unit of structure and function in all organisms.

(3) The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the growth and repair or upbuilding of protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

(4) Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals.

(5) Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system.

(6) All living organisms (except viruses and bacteriophage) carry on the common life processes; reproduction, growth, nutrition, excretion, respiration, and irritability.

(7) In the presence of sunlight the chloroplasts of chlorophyll-bearing plants convert carbon dioxide and water into intermediate substances, and these into sugar, and that into starch, and liberate oxygen; thus directly or indirectly producing practically all the food in the world.

(8) A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment.

(9) Cellular respiration (aerobic decomposition) occurs in all living cells and all organisms possess structures by means of which it can be carried on. Its first step is intake of oxygen either directly from the air or dissolved in water, its final product is carbon dioxide, and free energy is released. In the cells it is accomplished at ordinary temperatures by the intervention of special enzymes.

(10) Cells are organized into tissues, tissues into organs and organs into systems, the better

to carry on the functions of complex organisms.

(11) In organisms the end products of metabolism, water, carbon dioxide, and nitrogenous compounds, are either stored in the cells as insoluble crystals, are eliminated in solution by diffusion, or osmosis (excretion); are incorporated into useful cell products (secretion); or are recombined into food substances within the organism.

(12) Most cases of fermentation, souring and putrefaction are brought about by living microrganisms.

(13) Food, oxygen, certain optimal conditions of temperature, moisture, and light, are essential to the life of most living things.

(14) All the higher forms of terrestrial life are dependent either directly or indirectly on the soil bacteria for their nitrogen supply.

(15) In sexual reproduction a male cell from one parent unites with a female cell from the other parent to produce the young (except in the few cases of self-fertilization).

(16) All communicable diseases are caused by microorganisms.

(17) Protoplasm is the physical basis of all life.

(18) The multitude of interrelated neurons of the nervous system of higher animals form a complex system through which every organ of the body is in connection with every other organ.

(19) Living things alter their types; present species have not always existed, but have originated by descent from others which in turn were derived from still earlier ones, and so down to the first living forms.

(20) All living things respond to stimuli in their environment.

(21) The biological functions of color are to conceal, to disguise, or to advertise.

(22) A parasitic organism harms its host in various ways and to various degrees, by actively attacking the tissues, by shedding poisons (toxins) which are distributed throughout the body of the host, by competing with the host for food or even by making reproduction of the host impossible.

(23) All living things are slowly changing, both structurally and functionally, in response to changes in their physical environment.

(24) Every species of organism is subject to certain checks or controls in the form of enemies and only those members that are most capable of avoiding their enemies survive to reproduce new offspring and thereby transmit many of their characters to their offspring.

(25) Protective adaptations aid survival.

(26) Digestion in plants and animals is carried on by enzymes, or organic catalysts, which are made by the organisms themselves and which take part in and speed up the chemical reactions but do not undergo any permanent chemical change themselves.

(27) Enzymes, vitamins, and hormones are chemical regulators (stimulators and suppressors) of the reactions that occur in living organisms.

(28) Living things come only from living things.

(29) All plants and animals are engaged in a constant struggle for energy.

(30) The energy which makes possible the activity of most living things comes at first from the sun and is secured by the organism through the oxidation of food within its body.

(31) Regeneration is almost universal among living things; from the simple to the more complex animals the abilities to regenerate lost parts and to reproduce asexually fall off, gradually and independently, as the body becomes more specialized.

(32) All living cells require oxygen to provide energy or to build new protoplasm.

(33) Every cell consists essentially of a mass of protoplasm which is usually differentiated into a central portion, the nucleus, and an outer portion, the cytoplasm.

(34) Energy and matter are not created or destroyed in the reactions associated with the life processes, but are passed on from organism to organism in endless succession.

(35) Throughout the life of every organism there is a building up and a tearing down of protoplasm with constant transformations of energy.

(36) Infection by microorganisms is possible only under the following conditions: (1) The infecting organism must enter the host in sufficient numbers; (2) It must enter by an appropriate avenue; (3) It must be virulent; (4) The host must be receptive.

(37) Oxidation (combustion) furnishes the essential source of heat in the animal body; and other factors remaining constant, the more heat so produced the warmer the animal body.

(38) Saprophytic organisms are responsible for decay by which process the necessary raw materials for growth of new organisms are released from dead matter.

(39) Living things are not distributed uniformly or at random over the surface of the earth, but are found in definite zones and local regions where conditions are favorable to their survival.

(40) The antitoxins produced by the body of an organism are specific.

(41) The surface of the earth and the atmosphere surrounding the earth are undergoing constant changes; therefore in order to survive, organisms must migrate, hibernate,

aestivate, build artificial shelters or otherwise become adapted to these changes.

(42) Certain associations of plants and animals are the result of a struggle for survival, for example, community or social life, parasitism, and symbiosis.

(43) All living organisms have other living things which compete with them for the available energy.

(44) Water is essential to all living things because protoplasmic activity is dependent upon an adequate water supply.

(45) The germ plasm of animals and plants passes on from generation to generation and there has been a continuous stream from the first organisms to the present living organisms.

(46) Parent material for the development of soils is formed through the physical disintegration and chemical decomposition of rock particles and organic matter.

(47) From the lower to the higher forms of life, there is an increasing complexity of structure, and this is accompanied by a progressive increase in division of labor.

(48) The work of the chlorophyll of all chlorophyll-bearing plants is essential to all living things.

(49) Osmosis, the diffusion of molecules of a solvent (usually water) through a semipermeable membrane (a layer of cells or the membrane of a single cell) from the point of higher concentration of the solvent to a point of lower concentration, with a stoppage of the flow of molecules of the solute, is a basic process in plant and animal physiology.

(50) The continuance of higher forms of life in anything like the present kinds and numbers would be impossible without bacteria and molds. They break down the complex carbohydrate and protein substances of dead plants and animals into simpler substances which may then be used again by living plants.

(51) All life comes from preceding life.

(52) The organisms most likely to survive and reproduce are those that are structurally and physiologically best fitted to their environments.

(53) Certain one-celled organisms escape adverse conditions by forming highly resistant spores which often survive until conditions are again favorable.

(54) Every individual organism is composed of distinct hereditary characters which are transmitted by distinct hereditary factors (genes). In a hybrid the different parental genes are combined. When the sex cells of the hybrid are formed the two parental genes separate again, remaining quite unchanged and pure, each sex cell containing only one of the two genes of one pair.

(55) There is a cycle, from inorganic substances in the air and soil to plant tissue, thence to animal tissue, from either of the last two stages via excretion or death and decay back to the air and soil. The energy for this everlasting rotation of life is furnished by the radiant energy of the sun.

(56) All living things, except chemo-synthetic bacteria, depend directly or indirectly on photosynthesis for food.

(57) An animal cannot live without proteins. They are necessary in cell growth and maintenance; so are necessities in the diets of animals. Plants are able to use carbohydrates and nitrates to build up the proteins necessary for growth and maintenance of their cells.

(58) Energy can be transformed into mass and mass into energy, but the sum total, mass plus energy, remains constant.

(59) New kinds of living things have arisen through mutation.

(60) All gradations of association occur in intimate associations between organisms, from those which are mutually beneficial to the individuals concerned (symbiosis) to those in which one member secures all the advantage at the expense of the other.

(61) Digestion accomplishes two things; it makes food soluble in water, thus enabling the nutrients to pass through membranes and thereby reach and enter the cells; it reduces complex nutrients (fats, proteins, and carbohydrates) to simple building materials which in turn can be rebuilt into whatever living material or structural feature is necessary at the place of use.

(62) Except for those organisms which exhibit metagenesis, all living things are able in one way or another to produce new living things like, or nearly like, themselves.

(63) All plant and animal life, along with the climate and varying weather, plays an active part in helping to form and to change the soil.

(64) Carbon dioxide set free during the respiration of both plants and animals is absorbed by plants and used as a raw material of photosynthesis.

(65) There are no elements in living matter which are not found in its lifeless environment; the energy by which life is operated is the same energy by which the simplest physical and chemical transformations are brought about.

(66) In general, living things give evidence of a definite progression from simple to complex forms.

(67) Since the genes of the two parents combine

at random in the germ cells and since the germ cells meet at random in fertilization, the individuals of any generation occur in certain predictible ratios.

(68) The range of temperature for life activities is very narrow as compared with the range of possible temperatures. There is a minimum temperature below which, and a maximum temperature above which, no life processes are carried on. The temperature range for life processes is from many degrees below 0° C. to nearly the boiling point of water.

(69) The secretions of the endocrine glands are absorbed directly into the blood stream from the gland tissue that produces them and are absorbed from the blood by the tissues of the organs whose activities are regulated by these substances.

(70) In many multicellular organisms body form is secured and maintained either by the consistency of the tissues and the internal pressure of body fluids, or by the secretion of special substances which are formed into supporting structures.

(71) Diffusion, the spread of fluids with their dissolved substances, throughout the protoplasm of a cell or the tissues of an organism is an important method of conveying oxygen from the surface of a cell to the interior, or digested foods from the place of digestion to the protoplasm that will use them, or substances that stimulate any activity to the organ that responds to them, or the waste materials from the place where they are formed to the place where they are stored or excreted.

(72) The fundamental process of reproduction in all organisms whose cells possess nuclei is cell division which results in the precise distribution of the chromatin of the nucleus.

(73) The hereditary characters in all organisms are determined by the genes which are carried in the chromosomes.

(74) Decomposition of the carbon compounds of organisms provides a replenishment of carbon in the atmosphere in the form of carbon dioxide. Thus carbon is continually subjected to a series of cyclic changes from living to non-living substances.

(75) All individuals of the first generation of hybrids, the F_1 generation, are uniform in appearance in alternative inheritance; only one of the two parental characters, the stronger or the dominant one, is shown. In intermediate inheritance a mixture of the parental characteristics is shown.

(76) All living things, except a few anaerobes and autotrophic bacteria, secure their energy by oxidizing food.

(77) Each kind of living thing has its characteristic chromosome complement, and the constancy of that complement is preserved at each cell division. Different species show the utmost diversity in number, size, and form of chromosomes.

(78) In all organisms, increasing complexity of structure is accompanied by an increasing division of labor.

(79) The power of contraction which results in movement is possessed by all protoplasm to a greater or lesser degree.

(80) All cells produce certain chemical compounds, secretions, which may be used in the processes going on within the cell, in cavities adjoining the cells, or at considerable distances from the cells where they are produced.

(81) Every living species is continually producing a multitude of individuals, many more than can survive, varying more or less among themselves, and all competing against each other for the available energy.

(82) When the balance of nature is disturbed, disastrous results often follow.

(83) Reproduction in all organisms is a process of growth in which a single cell or a group of cells is separated from the parent body and develops into a new individual.

(84) All cells arise through the division of previous cells (or protoplasm), back to the primitive ancestral cell (or protoplasm).

(85) Each species of living organism is adapted, or is in the process of becoming adapted, to live where it is found.

(86) Plants and animals are directly or indirectly dependent on the soil.

(87) Anaerobic decomposition (fermentation) is accomplished at ordinary temperatures by the intervention of special enzymes; dissimilation occurs in the absence of oxygen; its final products are carbon dioxide and alcohol; and free energy is released.

(88) The smallest unit of living material capable of existing independently and of maintaining itself is the unit called the cell.

(89) All the modes of reproduction of organic life are alike in their nature, varying only in complexity of development. They fall into two general categories, asexual and sexual reproduction.

(90) All embryos start from a single fertilized egg cell and grow through division and redivision into the form of the organism which produces the egg cell.

(91) Sexual reproduction is an almost universal method of reproduction and occurs in representatives of every phylum of plants and animals.

(92) Oxygen free in the atmosphere or dissolved in water supplies the respiratory needs of practically all living organisms, except for a few parasitic and anaerobic animals, and

a number of bacteria and fungi which can extract the oxygen needed for their energy production from the organic substances on which they feed.

(93) The phenomena of life involve chemical change, so that wherever life processes are being carried on, chemical changes are taking place. However, chemical change may proceed without involving life.

(94) Every animal comes into the world with a certain inherited endowment of congenital behavior.

(95) Growth and repair are fundamental activities of all protoplasm.

(96) In a living organism adaptation of action and adaptation of structure are necessary for survival.

(97) In the second and later generations of a hybrid, every possible combination of the parent character occurs, and each combination appears in a definite proportion of the individuals.

(98) For each disease caused by an organism a specific microbe exists.

(99) Heredity supplies the native capacities of an organism; environment determines to a large extent how fully these capacities will be developed.

(100) Chlorophyll-bearing plants are adapted for food making.

CONCLUSIONS

In so far as the results of this investigation may be valid, the following conclusions seem justified:

(1) The "major" list of 300 principles of the biological sciences is composed of those principles of which a comprehension is necessary:

(a) For an understanding of the scientific (biological) materials appearing in textbooks in biology prepared for the secondary and junior-college levels of the public schools, and in books of a non-specialized nature prepared for the general reader.

(b) For an understanding of the scientific (biological) materials appearing in the public press and in non-specialized magazines.

(c) For an understanding of and interpretation of some of the scientific phenomena of everyday living.

(d) For a solution of some of the problematic situations frequently encountered in the everyday experiences of the average individual.

(2) The major list of biological principles is composed of principles which are at least well suited, if not ideally suited to serve as objectives of instruction in science in a program of general education.

(3) The minor list contains some of those principles of the biological sciences which are of importance for general education.

(4) Though the coefficients of correlation of the values of the principles are low, the fact that the major list contains 300 biological principles, a number that is far too great for inclusion in a course in science at the elementary level or in a course in biology at the secondary level, indicates that it should be possible to select for such courses those principles from the list which received high values for purposes of general education in all three analyses.

RECOMMENDATIONS

The list of principles of the biological sciences secured in this investigation should prove of value to classroom teachers and supervisors of biology; to subject-matter specialists engaged in the training of teachers of science for all levels of the public-school system; to committees engaged in the construction or revision of courses in biology, or of the science program as a whole; to curriculum workers who are concerned with the revision of the total instructional program of the public schools; and to the authors of textbooks for all grade levels, from the elementary school through the junior college in the following ways:

(1) As an index of the relative values of the important principles of the biological sciences, and of the degree of emphasis which should be given to the development of "functional understandings" of these principles in a program of general education.

(2) As a source of technically correct statements of the important principles of the biological sciences.

(3) As a source of those major principles which are suited to serve as objectives of instruction in science and around which the learning experiences of the curriculum in science can be organized and to the understanding of which these educational experiences can contribute.

(4) As a source of those "major understandings" in terms of which the results of instruction in science, as it appears in changed pupil behavior, may be evaluated.

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To help America maintain its top-flight position in science, an expansion of Battelle Memorial Institute's program of research education is being planned, Clyde Williams, Battelle director, has announced. Mr. Williams pointed out that the program will be of special interest to returning veterans who can qualify for training as research workers in the sciences.

The program, which will be directed at the graduate level of education, is an expansion of the plan which had been markedly successful thus far with Ohio State University.

"America has been so busy in the last five years applying the old familiar laws of nature to military purposes that we have had too little time for discovering new scientific laws. Building new post-war industries and products for mass consumption depends on a steady flow of new basic knowledge. Furthermore, this new knowledge is vitally important for national preparedness in the future. Battelle's expanded plan of research education, built on fifteen years of experience in this field, is designed to add to the country's store of scientific knowledge, as well as to train young scientists."

Thousands of veterans have become aware of the importance of technology from their battlefield experiences and will be interested in scientific or engineering careers. They are learning that scientific manpower is one of the country's key assets, and that the supply of such men is now, and will remain for years, critically short. Battelle Memorial Institute, in cooperation with other educational institutions, Williams declared, will give qualified veterans the finest possible training in scientific research on the professional level.

"Research education," said Williams, "is a familiar field for Battelle Memorial Institute. Hundreds of research men have been trained at Battelle, and many of these have carried its methods into the research laboratories of industry and into universities, government bureaus, and other scientific organizations throughout the country. The first Battelle fellowship was granted in 1930 and fellowships have been granted annually since that time. Another phase of Battelle's research education is the publication of the results of scientific research. These publications now total ten complete books, contributions in others, and more than 800 scientific papers and technical articles."

RECENT BOOKS AND ARTICLES

BOOK REVIEWS

Christofferson, H. C., Cahoon, G. P., Richardson, J. S., Fairchild, F. M., and Hamburg, M. *Demonstrations and Laboratory Experiences in the Science of Aeronautics.* New York: McGraw-Hill Book Company, 1945. 155 p. $2.00.

This book, prepared with the cooperation of the Civil Aeronautics Administration and the American Council on Education, fulfills an urgent need of those who feel that the science of aeronautics, in common with other sciences, should provide students with demonstrations and laboratory experiences. Detailed instructions are provided for the construction and operation of about 100 devices for use in teaching aerodynamics, power plants, meteorology, navigation, and communications. Many of these can be constructed by students. Each project is outlined in terms of purpose, materials required, notes on construction, and suggestions for use. Scale drawings, diagrams, and photographs are included.

While the manual is admittedly incomplete, it is unfortunate that the authors did not include some of the excellent devices being used by the Army Air Forces, e.g., a glass-sectioned weather diorama and plastic forms for illustrating map projections. More material could have been included in the section on power plants (engine instruments are neglected) and a simpler model of a wind tunnel could certainly have been found.

The book is, nevertheless, a valuable addition to the school or teacher's aeronautics library, and an essential for the school aviation club.

—Louis Teichman.

Blackwell, Gordon W. *Toward Community Understanding.* Washington: American Council on Education, 1943. 98 p.

Ivey, John E., Jr. *Channeling Research into Education.* American Council on Education Studies, Series I, Reports of Committees and Conferences, Number 19 (Volume VIII), August, 1944. 187 p.

Gordon Blackwell, on behalf of the Commission on Teacher Education, discusses the problem of giving to future teachers (1) facts about communities, (2) methods of getting such facts, and (3) some desire to use them to advantage. Dr. Blackwell, an associate in the Institute for Research in Social Science at Chapel Hill, understands community problems as well as teacher training.

He has examined special courses of training at Milwaukee, Chicago, and Columbus (Ohio State University)—each a course designed to give prospective teachers an insight into community structure and problems. He also reports several arrangements for training students in methods of fact-finding and community survey. His section "Toward Community Action" describes cooperative work between student-teachers and community in such varied areas as Michigan, Alabama, and North Dakota.

Actual community experience in student government, group living, work projects, arts, and development of teaching materials are next described, and some interesting, unconventional, and apparently successful projects are noted. Final chapters discuss the relation of college and community—in fact the whole range of relationships involved—summarizing with eight common-sense questions to serve as a basis for judging the merit of particular projects.

John E. Ivey, Jr., is, like Dr. Blackwell, an authentic southerner and here reports for the Southern Committee on Regional Studies and Education. His report is in a sense complementary to the other, for it deals with the problem of bringing into the schools, and through them into the community, the results of modern research in "physical, natural, and social sciences." In his words, "A study of the general problem of research translation is probably the most urgent need facing southern education." The report falls into two general sections: the first indicating the importance and character of southern regional resource education; the second appraising existing sources and methods.

Dr. Ivey makes a clear case for the possibilities of southern resource development through general understanding and participation. He also shows that a wealth of material is available for use, but believes that it needs to be integrated by state and regional agencies.

Readers not fully acquainted with the background from which these books come must not mistake either for an attempt to formulate a complete philosophy of education. Such is certainly not the intent of either author. A casual reader might also regard each thesis as an innovation in educational theory and practice.

Actually, the ancient role of education, in its anthropological sense, is to integrate the student with his community and acquaint him with what is known, that is, "research." It is not a new phenomenon to have education outstripped by a vital culture which gets ahead by short-circuit. When this happens, the end-products of education